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Colours of Minor Bodies in the Outer Solar System

II - A Statistical Analysis, Revisited

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ABSTRACT

We present an update of the visible and near-infrared colour database of Minor Bodies in the outer Solar System (MBOSSes), now including over 2000 measurement epochs of 555 objects, extracted from 100 articles. The list is fairly complete as of December 2011. The database is now large enough that dataset with a high dispersion can be safely identified and rejected from the analysis. The method used is safe for individual outliers. Most of the rejected papers were from the early days of MBOSS photometry. The individual measurements were combined so not to include possible rotational artefacts. The spectral gradient over the visible range is derived from the colours, as well as the R absolute magnitude $M(1,1)$. The average colours, absolute magnitude, spectral gradient are listed for each object, as well as their physico-dynamical classes using a classification adapted from Gladman et al., 2008.

Colour-colour diagrams, histograms and various other plots are presented to illustrate and investigate class characteristics and trends with other parameters, whose significance are evaluated using standard statistical tests.

Except for a small discrepancy for the $J-H$ colour, the largest objects, with $M(1,1) < 5$, are not distinguishable from the smaller ones. The larger are slightly bluer than the smaller ones in $J-H$. The Plutinos and other Resonant Objects, hot Classical Disk Objects, Scattered Disk Objects and Detached Disk Objects have similar properties in the visible, while the cold Classical Disk Objects and the Jupiter Trojans form two separate groups for their spectral properties in the visible wavelength range. The well known colour bimodality of Centaurs is confirmed. The hot Classical Disk Objects with large inclination, or with large orbital excitation are found bluer than the others, a result that was also previously known. Additionally, the hot Classical Disk Objects with a smaller perihelion distance are bluer than those which do not come as close to the Sun. The bluer hot Classical Disk Objects and Resonant Objects have fainter absolute magnitudes than the redder ones from the same class.

Finally, we discuss possible scenariis for the origin of the colour diversity observed in MBOSSes, i.e. colouration due to evolutionary processes and due to formation.

The colour tables and all the plots are available on-line at http://www.eso.org/ ohainaut/MBOSS, which will be updated when new measurements are published.

Key words. Comets: general – Kuiper Belt: general – Methods: photometry – Methods: statistical –

1. Introduction

Minor bodies in the outer Solar System (MBOSSes) comprise objects in the Kuiper Belt (KB) and more generally in the Transneptunian (TN) region, as well as small bodies in the giant planets region that came from the KB or TN regions, but are now no longer immediate member of these environments. Centaurs are considered escapees (Gladman et al. 2008; Kavelaars et al. 2008), scattered from the KB and TN environment towards the Sun, possibly also representing a major source of the short-periodic comets (SPCs). Some MBOSSes might also be found among the satellites of the giant planets since they may have been stranded there by gravitational capturing from the Centaur population (Duncan and Levison 1997). Another large population of MBOSSes can be found as long-periodic (LPCs) or Oort Cloud comets. These objects are believed to have formed in the region of the giant planets and be scattered afterwards into the very distant domains of the

Solar System (Dones et al. 2004), although presently it cannot be excluded that contaminators of extra-solar comets (Levison et al. 2010) may exist among the Oort Cloud population.

MBOSSes in the planetary system environment are formed and have evolved in the region of the giant planets. They are considered remnants of the planetesimal population, however, not necessarily in the distance range where they are found today. Nonetheless, they may contain valuable information on the environment and the physical conditions at the time of their formation. On the other side, the long presence in the distant region of the planets and beyond may have caused alterations of physical properties of MBOSSes: for instance, high energy and particle radiation is suspected to modify colours and albedos of materials in space (de Bergh et al. 2008) and collisions can affect the body as a whole (fragmentation or growth) or in parts (resurfacing by excavated material). It can also not be excluded that intrinsic activity may have changed the surface constitution of the MBOSSes, since a number of ices, believed or known to be present in these objects, can sublimate at very large distances from the Sun (Delsemme 1982; Meech and Svoren 2004, for instance CH_4, CO, and N_2 up to about 45, 65 and 80AU, respectively;). Last, but not least, larger MBOSSes may have experienced alteration of their internal structure (McKinnon et al. 2008). It is thus of interest to characterize population properties and to explore possible connections with the origin of the bodies and/or their evolutionary pathways in the Solar System.

With this study we focus on photometric properties of MBOSSes and the characterization of different dynamical populations among them. The photometric properties comprise of published measurements of photometric brightnesses and filter colours of the objects or of spectral slopes of the reflected continuum light in the visible and near-infrared (IR) wavelength regions (Doressoundiram et al. 2008). The brightness of the objects is a first indicator on their size and albedo while filter colours allow a coarse characterization of the spectral energy distribution of reflected light from the objects and may provide constraints on the surface properties, i.e. the wavelength dependant reflectivity and in exceptional cases possibly also on surface chemistry.

The visible and near-IR wavelength region up to 5μm show surface reflected sunlight, i.e. essentially a bluish, neutral or reddened solar spectrum, occasionally with imprinted absorptions from specific surface materials. Continuum colours and gradients are well defined, maybe with the exception of the $HK(LM)$ bands for objects with very strong ice absorption features (Trujillo et al. 2011). Photometric parameters of MBOSSes and their correlations with dynamical and other properties of the bodies were analysed in the past using various different datasets and statistical methods (for a review, see Doressoundiram et al. 2008, and references therein). Key findings are: the TNOs cover a wide range of colours and spectral slopes in the visible from slightly bluish (-5 to -10%/100 nm) to very red (40 to 55%/100 nm) while in the near-IR they display a fairly narrow dispersion around solar colours. Differences in the wavelength dependent surface reflectivity were noted for dynamically hot and cold Classical Disk Objects (CDOs), with the latter representing a very red population in the Solar System. An anti-correlation with high significance between the surface reddening and inclination and excentricity among the hot CDOs was interpreted as indicator for evolutionary changes due to impacts and cosmic radiation (Trujillo and Brown 2002; Peixinho et al. 2008). Centaurs may have a bimodal colour distribution with a neutral to slightly red and a very red sub-population (Tegler et al. 2008). A number of weaker correlations between photometric and dynamical properties of KBOs are addressed in literature. However, no clear convincing picture with quantitative modeling results has evolved, although various attempts of a qualitative understanding of the surface colours as results of evolutionary processes of the surface in the outer space environment have been published (for a brief review see Doressoundiram et al. 2008).

In many cases the published colour and spectral gradient analyses rely on different datasets collected at different telescopes/instruments and by different groups. The sample sizes were growing with time reaching meanwhile more than 100 TNOs and Centaurs. A summarizing database of MBOSS colours comprising data from many different papers were first compiled and analyzed by Hainaut and Delsanti (2002, hereafter Paper I) and was publicly accessible through the internet; it is still available at `http://www.eso.org/~ohainaut/MBOSS/` , but is superseded by this work.

In this paper we provide a version of this MBOSS colour database that has been updated both in terms of populations and collected data. It can be used either for population-wide analysis, as done in this paper, or to support other works on specific objects or group of objects, either relying on the averaged data presented here (e.g. to get the colour of a given object), or by going back to the original publications which are listed for each objects. We present new statistical analyses of the MBOSS populations, based upon an enhanced database of photometric brightness and colour measurements of the object published in literature and applying qualified selection criteria to the data. The content of the database, both in terms of populations and collected data, is up-to-date for end of 2011. The qualifying criterion of the data are described in Section 2. Section 3 introduces the statistical methods and their application goals for the MBOSS analysis and outlines the results achieved. Possible interpretations of the findings related to their formation and evolutionary pathways are discussed in Section 4. The paper ends with a brief summary of the major findings and of open and/or controversial issues as well as prospects for their clarification in Section 5.

2. Description of the database

The database collects photometric information of MBOSSes, namely of objects in the Kuiper Belt (KBOs) and in the immediate Transneptunian region, of the Centaurs, of short-periodic (SPCs), long-periodic and Oort Cloud comets and of Jupiter Trojans. It does not contain information on satellites of the giant planets as far as they are considered to be captured MBOSSes, nor of Trojans of other planets. The objects are listed under their current official designation, i.e. number and name if available, or number and provisional designation, or provisional designation only.

For objects presenting cometary activity, the measurements collected here refer to the nucleus, not to the dust and gas component. In the case of objects with satellites, measurements for the whole system are listed under the main designation (e.g. 26308 = 1998SM165), while an individual member of the system is indicated by a suffix (+B for the first satellite, for instance 134340-Pluto+B refers to Charon). In the statistical analysis, the satellites are not given a special status: they just count as individual objects.

The photometric information in the database comprises magnitudes or filter colours in the $UBVRIJHKL$ broadband filter system for the visible and the near-infrared. In rare cases also spectral gradients and/or colours measured from spectroscopic data of MBOSSes were entered, relying on the spectrum to colours conversion presented in the original paper.

All flavours of the main filters are considered together without any conversion. For instance, in this database, Bessell R, Kron-Cousin R and r are directly listed as R. Most authors calibrate their system using Landolt (1992), thereby naturally unifying these subtly different systems. More exotic filters are included in the database, but not used in this study.

The literature is searched for relevant papers, using the SAO/NASA ADS[1], the distant EKO newsletter[2], the Neese (2011) compilation of TNO and Centaurs at the Planetary Data System[3], the astroPh preprints from arXiv[4].

Only magnitude measurements that are explicitly presented as simultaneous are considered as a single epoch. This means that the individual filters must have been observed in a sequence, so that no more than ∼1h elapsed during a colour measurement. The only exception was for average colours obtained from full light-curves. By default spectral gradients and colours obtained from spectroscopy fulfill the "simultaneity" criterion. Photometric measurements obtained non simultaneously are listed as separate data, and are not used for the average colour estimates. The method used to carefully combine measurements from different epochs without introducing colour artifacts from a possible lightcurve is the same as in Paper I.

The original database, described in Paper I, contained information on only 104 objects. We did not have the means of evaluating the quality of the measurements, nor the luxury to reject some of them. The online-version continuously grew, listing up to 400 objects. The current version of the MBOSS database includes over 550 objects, with over 2000 measurements extracted from about 100 papers. We can now afford to reject some measurements, based upon a careful and quantifiable approach. The process of cleaning data is dangerous, as it could potentially select against special or interesting objects. We developed a method to evaluate the quality of a data-set that is robust against genuine outliers. As first noticed by Boehnhardt et al. (2001), and discussed later in this paper, most objects present a fairly linear reflectivity spectrum over the visible wavelength range; we used this characteristics to assess the quality of a set of measurements. For each individual measurement, the distance between the data point in a colour-colour diagram and the Reddening line (locus of the objects with a linear reflection spectrum, see Section 2.3) is computed as follows. Let (Cx, Cy) be the colours of the object, and (Cx, Fy), (Fx, Cy) the two points on the reddening line that have the same x and y as the data point, respectively. The distance estimator is defined as

$$d = \sqrt{\sum_{i=1}^{n} \frac{(C_i - F_i)^2}{n}} , \qquad (1)$$

where the C_i and F_i terms are the coordinates in the $B - V/V - R$ and $V - R/R - I$ colour-colour diagrams where available, and n the number of coordinates available (2 or 4). The overall quality estimator for a data-set is

$$D = \sqrt{\sum_{k=1}^{N} \frac{d_k^2}{N}} , \qquad (2)$$

where d_k are the individual distances, and N the number of measurement sets in the considered paper. D behaves like an error on the photometry, expressed in magnitude. Each of the papers

[1] http://adswww.harvard.edu/

[2] http://www.boulder.swri.edu/ekonews/

[3] http://sbn.psi.edu/pds/resource/tnocencol.html

[4] http://arxiv.org/archive/astro-ph

with $D > 0.25$ was scrutinized. The faintest objects were flagged out and D re-estimated. If D remained above 0.25, the process was iterated. In some cases, this brought D below 0.25, and the remaining measurements are retained, considering that those rejected were affected by low S/N. In other cases, the dispersion of the measurements is not correlated with magnitude, and the full data-set is flagged out; we consider that a problem affected the whole paper. This happened for instance to some papers from the early time of MBOSS photometry. Before flagging a data-set or a measurements out, the colours were compared with other measurements of the same object, if available, so to preserve objects with intrinsic unusual spectra. Also, it must be noted that the majority of the objects do have a linear spectrum, so even a few objects with non linear spectrum do not affect much the overall D estimator of a paper (thanks to the quadratic average), and these objects are then preserved in the database.

This method obviously works only for measurements in the visible range. On the 102 papers considered, 33 did not have suitable data, and 7 were globally rejected. For each data-set (including IR-only papers), outliers were individually considered. Only the points that we have a strong reason to believe were affected by a problem were rejected (for instance if a note in the paper reports a problem). Also, some papers that concentrate on objects with exceptional spectra were obviously preserved. We believe that this statistical approach to the cleaning process with a careful and conservative *a posteriori* assessment ensures a better quality of the global data-set.

The database as presented in this paper, is available online[5], together with all the plots related to this static version of the database, as a reference. In parallel, as the database is evolving with addition of new measurements, another up-to-date version[6] is also available, also with all plots and tables. The former should be used only in direct reference to this paper, while the dynamically updated version can be used for further generic studies on MBOSSes. The updated version is produced exactly as the static one presented in this paper, with additional objects and measurements processed as described above.

2.1. Content of the database

Internally, each record lists the object designation as on the original publication (i.e. typically using the temporary designation for early papers, and the final number in later papers). These are converted to the current official designation, i.e. number and name if available, or number and provisional designation, or provisional designation only.

The internal database lists the measurements for each epoch. One record is constituted by the name of the target, the epoch of the measurements, the reference to the original paper, and the list of measurements for that epoch as they appear in the paper, ie as magnitudes, colours, or a combination.

The orbital elements are retrieved from the MPCORB file, regularly updated from the MInor Planets Center (MPC) website[7]. These elements are used to compute the position of the object at the epoch of the observations (if available). The orbit semimajor axis a, perihelion q, eccentricity e, inclination i, orbital excitation defined as $\mathcal{E} = \sqrt{\sin^2 i + e^2}$, and the helio- and geocentric distances r and Δ as well as the solar phase α at the time of the observations are stored with the individual measurements.

The measurements are averaged as in Paper I: For a given epoch, the matrix of all possible colours is populated from the magnitudes and colours available at that epoch – but not mixing different epochs. The average colours for an object are then obtained as a weighted average of the corresponding colours, using $1/\sigma$ as the weight, where σ is either the reported or propagated error on the individual colour measurements.

Additionally, for each epoch, we convert the R magnitude (either reported, or obtained from another magnitude together with the corresponding colour index) into an absolute $M(1,1,\alpha)$ magnitude with the computed r and Δ using $M(1,1,\alpha) = R - 5\log(r\Delta)$. As in Paper I, we do not make any assumption on the solar phase function, and do not correct for solar phase effect. The $M(1,1,\alpha)$ obtained for different epochs are then averaged into a final absolute R magnitude, which is reported as $M(1,1)$ in Table 2. The solar phase effects are not considered. Indeed, the observations are obtained at small solar phase angles because of the distance of the objects, and because most of the observations are acquired close to opposition. The colours of the objects, whose study is at the core of this paper, are even less affected than the absolute magnitude. We also do not make any assumption on the albedo of the object, and therefore do not convert the absolute magnitudes into diameters.

For each object, the slope of the (very low resolution) reflectivity spectrum obtained from the average colour indices (Jewitt and Meech 1986) is computed as in Paper I, via a linear regression

[5] http://www.eso.org/~ohainaut/MBOSS/MBOSS2_reference
[6] http://www.eso.org/~ohainaut/MBOSS
[7] http://www.minorplanetcenter.net/iau/Ephemerides/

over the $B - V - R - I$ range (assigning a lower weight to the B reflectivity), where most objects display a linear reflectivity spectrum (Boehnhardt et al. 2001). This gradient, S, is expressed in percent of reddening per 100 nm.

2.2. Physico-dynamical classes

Since the publication of Paper I, the understanding of the dynamical classes in the outer Solar System has greatly progressed. Paper I used fairly arbitrary definitions of the dynamical classes; moreover, the fairly small number of objects in each class did not allow for a fine-grained classification. In this paper, we use the dynamical classes defined by Gladman et al. (2008) (now so-called the SSBN08 classification, from the book in which it is published). The membership of the object is allocated using a combination of integration of the orbit over time together with cut-off in the orbital element space.

For this paper, we relied on the membership list published by Gladman et al. (2008), to which about 200 objects have been added from a list generated by C. Ejeta and H. Boehnhardt (private communication) in the context of the Herschel Key Program "TNOs are Cool" (Müller et al. 2009). This list was completed by the MPC catalogue of Jupiter Trojans[8]. For the objects not included in these lists, we determine the dynamical class using a simplified method: objects with an obvious designation (Long Period Comets, Short Period Comets) are first flagged as such, then for the remaining few objects (26 objects in the current database), we used algorithm based only on the osculating orbital elements, without integration of the orbit, directly inspired by the flow-chart Fig. 1 in Gladman et al. (2008). Furthermore, we split the classical TNOs between dynamically hot classical disk objects (with $i \geq 5°$) and dynamically cold classical disk objects ($i < 5°$). The arguments for this separation of CDOs come from the analysis of the orbital properties, although the first indications for the presence of different sub-populations among the classical TNOs came from a photometric study of TNOs by Tegler and Romanishin (2000) and were further evaluated in papers by Trujillo and Brown (2002) and Doressoundiram et al. (2002). The dynamical aspects are addressed in Morbidelli et al. (2008) and Gladman et al. (2008). We have chosen an inclination of 5° for the separation of the two populations. A split based around orbital excitation $\mathcal{E} = 0.12$ gives similar results (only 3 objects over the 89 cold Classical TNOs change class). Also following Gladman et al. (2008), we distinguish TNOs as member of the scattered disk (SDOs) and of the detached disk (DDOs). The majority of 'Resonant' objects belongs to the class of Plutinos in 3:2 resonance with Neptune. Objects belonging to other resonances are summarized as 'Res.others' objects in the analysis below. Finally, some of the Short Period Comets with Centaur-like orbital elements, as defined in Gladman et al. (2008) are re-assigned to that class, following Jewitt (2009a) and Tegler et al. (2008): 29P/Schwassmann-Wachmann 1, 30P/Oterma, 165P/LINEAR, 166P/2001 T4, 167P/2004 PY42 174P aka 60558 Echeclus, C/2001 M10 (NEAT), P/2004 A1 (LONEOS), and P/2005 T3 (Read).

2.3. The database

Table 1 lists the classes considered and the number of objects in each class. Table 2 provides examples of individual objects, listing the object identification and its dynamical class together with the main average colours, the spectral gradient $\mathcal{S}$, and the absolute R magnitude $M(1, 1)$. The full table is available in the online supplement.

[8] http://www.minorplanetcenter.net/iau/lists/JupiterTrojans.html

Table 1. Object physico-dynamical classes (see text for the definitions) and number of objects in each class, and some statistics about the overall database.

Class	Number
Jupiter Trojans	80
Resonant (3:2)	47
Resonant (others)	28
Long-periodic Comets LPCs	14
Short-periodic Comets SPCs	136
Centaurs	35
Scattered Disk Objects SDOs	30
Detached Disk Objects DDOs	28
Cold Classical Disk Objects (cold CDOs)	89
Hot Classical Disk Objects (hot CDOs)	68
Database	
Objects	555
Epochs	2045
Papers	100

Table 2. Object class and colour data for some example objects. The full table is available in the online supplement

Object	Class[1]	Epochs[2]	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
1P/Halley	SP Comet	2	13.558 ± 0.596	4.266 ± 2.015	0.720 ± 0.040	0.410 ± 0.030	0.390 ± 0.060	—	—	—
9P/Tempel 1	SP Comet	14	14.560 ± 0.460	9.959 ± 0.826	—	0.468 ± 0.010	0.469 ± 0.013	—	—	—
1172-Aneas	J.Trojan	2	8.729 ± 0.042	9.261 ± 0.863	0.727 ± 0.030	0.510 ± 0.022	0.400 ± 0.030	1.577 ± 0.036	0.430 ± 0.042	0.135 ± 0.036
1994 ES_2	Classic Cold	1	7.509 ± 0.130	—	—	—	—	—	—	—
1997 SZ_{10}	Res.(other)	1	8.148 ± 0.060	28.167 ± 2.909	1.140 ± 0.080	0.650 ± 0.030	—	—	—	—
1999 CF_{119}	Detached	3	6.933 ± 0.133	14.704 ± 4.163	—	0.622 ± 0.115	0.365 ± 0.106	—	0.380 ± 0.226	—
1999 CX_{131}	Res.(other)	3	6.910 ± 0.107	19.521 ± 4.293	0.918 ± 0.124	0.664 ± 0.128	0.434 ± 0.105	—	0.370 ± 0.238	—
2003 HX_{56}	Classic Hot	1	7.030 ± 0.209	-1.963 ±13.676	—	0.350 ± 0.226	0.260 ± 0.459	—	—	—
2060-Chiron	Centaur	34	6.092 ± 0.069	0.114 ± 0.996	0.700 ± 0.020	0.361 ± 0.017	0.325 ± 0.023	1.199 ± 0.110	0.294 ± 0.079	0.065 ± 0.094
5145-Pholus	Centaur	41	7.165 ± 0.076	48.354 ± 1.930	1.261 ± 0.121	0.788 ± 0.036	0.822 ± 0.054	2.612 ± 0.048	0.391 ± 0.047	-0.037 ± 0.047
12917-1998 TG_{16}	J.Trojan	2	11.388 ± 0.073	11.839 ± 1.962	0.724 ± 0.042	0.537 ± 0.042	0.410 ± 0.069	1.707 ± 0.066	0.475 ± 0.086	0.205 ± 0.081
15760-1992 QB_1	Classic Cold	5	6.979 ± 0.094	27.538 ± 4.806	0.869 ± 0.143	0.707 ± 0.093	0.651 ± 0.166	—	—	—
15809-1994 JS	Res.(other)	2	7.479 ± 0.160	28.194 ± 6.000	—	0.760 ± 0.170	0.480 ± 0.149	—	0.460 ± 0.705	—
19308-1996 TO_{66}	Classic Hot	16	4.520 ± 0.042	2.077 ± 2.168	0.671 ± 0.057	0.389 ± 0.043	0.356 ± 0.053	0.997 ± 0.101	—	—
20000-Varuna	Classic Hot	8	3.455 ± 0.090	26.843 ± 1.917	0.906 ± 0.052	0.637 ± 0.040	0.628 ± 0.040	2.010 ± 0.050	0.564 ± 0.070	-0.038 ± 0.105
20161-1996 TR_{66}	Res.(other)	1	—	—	—	—	—	—	0.470 ± 0.296	—
24835-1995 SM_{55}	Classic Hot	10	4.332 ± 0.040	0.272 ± 1.805	0.652 ± 0.032	0.357 ± 0.043	0.356 ± 0.052	1.010 ± 0.050	-0.270 ± 0.163	—
35671-1998 SN_{165}	Classic Cold	6	5.679 ± 0.320	6.857 ± 3.068	0.712 ± 0.095	0.444 ± 0.078	0.437 ± 0.083	1.270 ± 0.050	—	—
42355-Typhon	Scattered	12	7.252 ± 0.054	12.657 ± 1.354	0.758 ± 0.039	0.525 ± 0.022	0.414 ± 0.053	1.560 ± 0.045	0.406 ± 0.087	0.160 ± 0.071
42355-Typhon+B	Scattered	1	—	9.763 ± 0.000	—	—	—	—	—	—
50000-Quaoar	Classic Hot	4	2.220 ± 0.029	29.224 ± 1.706	0.958 ± 0.035	0.650 ± 0.020	0.610 ± 0.028	2.180 ± 0.058	0.360 ± 0.050	0.030 ± 0.057
52747-1998 HM_{151}	Classic Cold	1	7.417 ± 0.100	24.891 ± 4.691	0.930 ± 0.090	0.620 ± 0.050	—	—	—	—
90377-Sedna	Detached	3	1.077 ± 0.065	32.954 ± 2.972	1.131 ± 0.079	0.686 ± 0.077	0.657 ± 0.067	2.320 ± 0.060	0.290 ± 0.222	0.050 ± 0.314
90482-Orcus	Res. 3:2	6	1.982 ± 0.099	2.761 ± 1.831	0.664 ± 0.041	0.370 ± 0.039	0.390 ± 0.045	1.070 ± 0.042	0.120 ± 0.051	0.053 ± 0.055
134340-Pluto	Res. 3:2	4	-0.881 ± 0.400	7.607 ± 0.681	0.867 ± 0.016	0.515 ± 0.035	0.400 ± 0.010	—	—	—
134340-Pluto+B	Res. 3:2	1	—	3.334 ± 0.000	0.710 ± 0.002	—	—	—	—	—
134340-Pluto+C	Res. 3:2	1	—	-2.234 ± 0.000	0.644 ± 0.028	—	—	—	—	—
134340-Pluto+D	Res. 3:2	1	—	18.074 ± 0.000	0.907 ± 0.031	—	—	—	—	—
136108-Haumea	Classic Hot	3	0.217 ± 0.030	-0.010 ± 0.850	0.631 ± 0.025	0.370 ± 0.020	0.320 ± 0.020	1.051 ± 0.020	-0.044 ± 0.037	-0.111 ± 0.048
136199-Eris	Detached	64	-1.462 ± 0.036	3.866 ± 0.823	0.805 ± 0.015	0.389 ± 0.049	0.363 ± 0.061	0.849 ± 0.108	0.080 ± 0.072	-0.280 ± 0.085
136472-Makemake	Classic Hot	1	—	4.693 ± 0.900	0.828 ± 0.022	—	—	—	—	—
...										

(1) Classes refer to Gladman et al, SSBN07. M11 is the absolute *R* magnitude (2) Number of epochs.

Table 3. For some objects, list of the references used, and number of epochs. The full table is available in the online supplement

Object	References	Nr.
1994 ES_2	Green et al. (1997)	1
7066-Nessus	Davies et al. (1998)	
	Romanishin and Tegler (1999)	
	Bauer et al. (2003)	
	Davies (2000)	
	Tegler and Romanishin (1998)	17
15760-1992 QB_1	Jewitt and Luu (2001)	
	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2001)	
	Benecchi et al. (2011)	
	Romanishin et al. (1997)	5
19308-1996 TO_{66}	Jewitt et al. (2007)	
	Jewitt and Luu (1998)	
	Romanishin and Tegler (1999)	
	Hainaut et al. (2000)	
	Gil-Hutton and Licandro (2001)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Boehnhardt et al. (2001)	
	Sheppard (2010)	
	Barucci et al. (1999)	
	Davies (2000)	
	Tegler and Romanishin (1998)	16
...		

Table 3 shows examples for the list of references per object that were included in this study; the information for all objects is given in the online supplement. Figure 3 shows examples of the coarse reflectivity spectra for a set of objects obtained from their filter photometry. All of them are available on the MBOSS site.

Figure 1 presents some of the representative colour-colour diagrams. As a reference, the solar colours are indicated by a red star (see Paper I, Table 2 for a list of the solar colours and their references). The red Reddening line, introduced in Paper I, marks the locus of objects with a perfectly linear reflectivity spectrum over the considered colours, with a tick mark every 10 units of $\mathcal{S}$. For colour diagrams in the visible range, the distance from a data point to the reddening line therefore indicates a bent in the reflectivity spectrum. The symbols used indicate the dynamical class, and are explained in Fig. 2. The other colour-colour diagrams are available on the MBOSS site.

Figure 7 displays the spectral gradient S as a function of the main orbital elements, the orbital excitation, and the $M(1,1)$ magnitude of the objects. Other similar plots, for all the colours, are available online. The symbols indicate the dynamical class.

Figure 4 shows the histogram and the cumulative distribution for an example colour, for the spectral gradient, and for the absolute magnitude. Other similar plots are available on-line.

3. Results from the statistical analysis of the enhanced MBOSS database

3.1. Statistical tools

Comparing distribution by comparing their histograms "by eye" is unreliable: the size of the bins can cause artifacts or hide real features, and what appears as a strong difference can actually be of no significance. Similarly, the eye is a very powerful tool to detect alignments and clustering, even when these are not significant.

The colour, spectral gradient and $M(1,1)$ distributions of the various MBOSS populations were therefore compared using a set of simple statistical tests that quantifies the significance of the apparent differences, i.e. the t-test, the f-test and the Kolmogorov-Smirnov test. The tests are described in detail in Appendix B of Paper I and references therein; in brief:

- The Student t-test indicates whether the mean values of the two distributions are statistically different. The implementation used here deals properly with distributions with different variances.
- The f-test considers whether two distributions have significantly different variances.
- Finally, the Kolmogorov-Smirnov (KS) test uses the whole information contained in the distributions (and not just their means and variances) to estimate whether they are different.

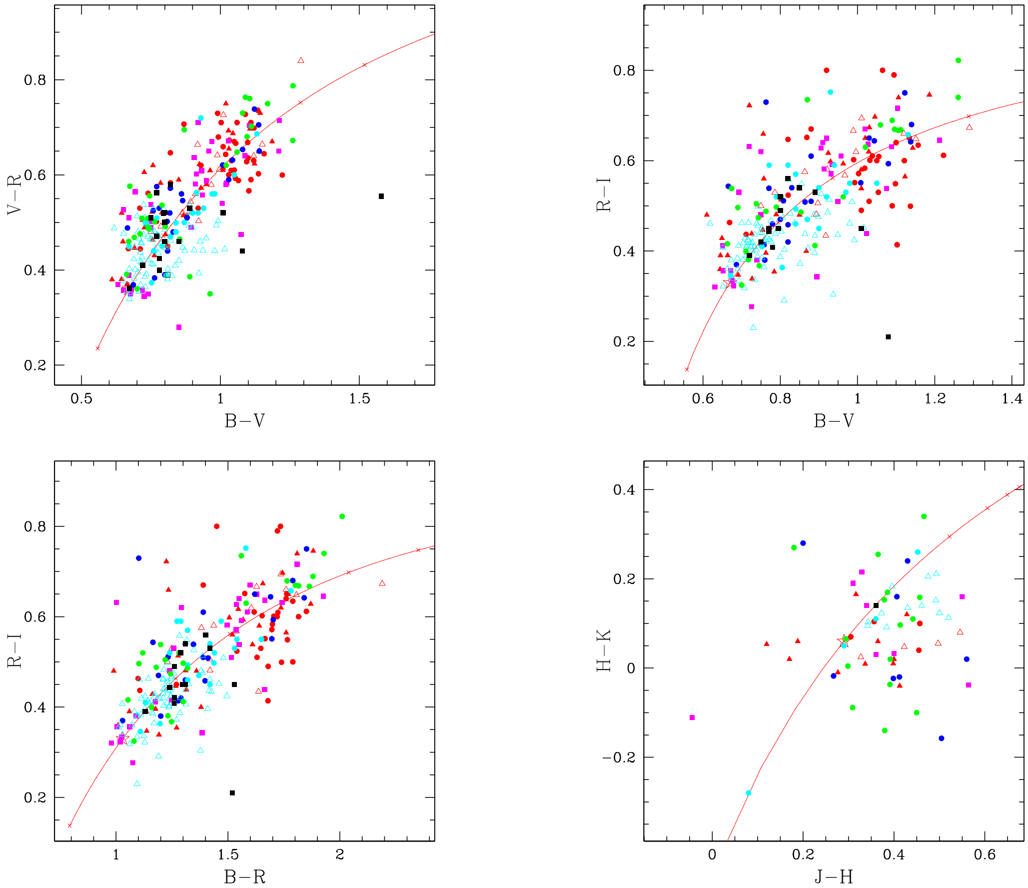


Fig. 1. Selected colour-colour diagrams of the objects. The physico-dynamical class of the objects is identified by their symbols, which are explained in Fig. 2. The red star indicates the solar colours, and the red line is the locus of objects with a flat reflection spectrum. The other colour combinations are available on the MBOSS2 site.

For these tests to give meaningful results, the samples compared must be sufficiently large. We set the threshold at 15 units for *t*- and f-tests, and at 20 units for the KS test.

3.2. The case of the brightest objects

Large KBOs have non-typical surface properties (eg, high albedo –Stansberry et al. (2008), or flatter spectral gradients) that are likely influenced by or the result of intrinsic processes overwriting the surface signatures from formation and/or from the evolution due to their environment. For instance, Pluto is known to have a tenuous, but captured atmosphere that can re-deposit on the surface (Stern and Tholen 1998; Protopapa et al. 2008) while (136199) Eris has an extremely high albedo (Sicardy et al. 2011). We therefore decided to remove the intrinsically brightest objects from the database for some studies, so that their potentially different characteristics does not pollute the colour distributions of the other, "normal" MBOSSes. In order to select a cut-off value, we estimated the radius of the objects whose escape velocity v_{esc} is equal to the velocity of material ejection via cometary activity v_{ej}. The escape velocity is given by

$$v_{esc} = \sqrt{\frac{2GM}{R}}, \tag{3}$$

where G is the gravitational constant, M the mass of the object, and R its radius. Assuming a density $\rho \sim 1000$kg m^{-1} to get the mass from the volume of the object,

$$v_{esc} \sim 7.5\ 10^{-4} R, \tag{4}$$

in IS units. To estimate the velocity of material ejection, v_{ej} (in m s^{-1}), we use the relation

$$v_{ej} = 580\ r^{-0.5} \sqrt{\frac{\mu_0}{\mu}}, \tag{5}$$

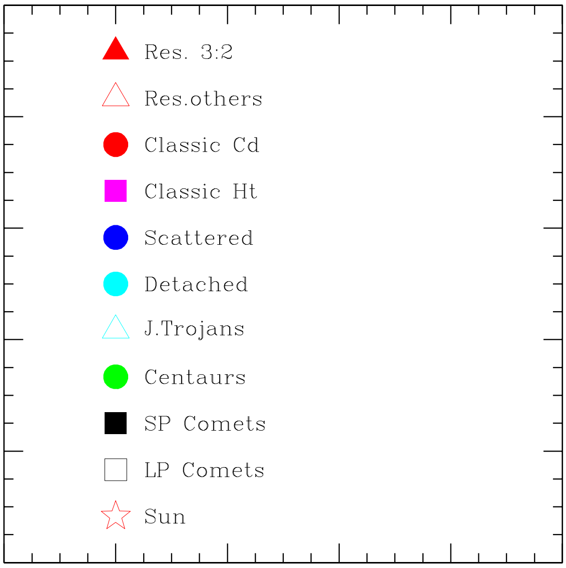


Fig. 2. Legend of the symbols used thorough this paper.

Table 4. Averge colour and dispersion of all MBOSSes (excluding Trojans), comparing those with $M(1,1) < 5$ with those with the others.

Colour	N	Aver./σ	N	Aver./σ	$t-Prob$	$f-Prob$
	$M(1,1) < 5$		$M(1,1) \geq 5$			
$J-H$	22	0.27± 0.25	84	0.41± 0.20	0.025	0.149
$H-K$	16	0.04± 0.07	31	0.07± 0.12	0.279	0.036

Notes: The q cut-off is set at the median value; N is the number of measurements; $t-Prob$ and $f-Prob$ are the probabilities that the two sub-samples are randomly extracted from the same distibution, evaluated with the $t-$ and $f-$tests. The other colours show insignificant differences.

where r is the heliocentric distance in AU, and μ_o/μ the ratio of the molecular mass of the species driving the activity to that of water. This relation was obtained by measuring the expansion of cometary comae, and is supported by a theoretical analysis —see Delsemme (1982) for a discussion. That velocity is the terminal velocity of the gas in the case of a small comet; it is directly controlled by the thermal velocity of the sublimating gas. For the TNOs, we use $\mu_o/\mu = 0.64$ for CO. Equaling $v_{\rm ej}$ and $v_{\rm esc}$, we obtain a critical radius R_c above which an object is likely to retain some of the material ejected by cometary activity,

$$R_c \sim \frac{6.2\ 10^5}{\sqrt{r}}. \tag{6}$$

R_c is in m and r in AU. Delsanti et al. (2004) discuss the evolution of R_c with different species and distance. For our purpose, it is enough to say that $R_c \sim 150$ km at $r = 17$ AU and 100 km at 43 AU. Stansberry et al. (2008), based on their large set of measurements with the Spitzer Space Telescope, indicate that large TNOs have higher than average albedo. We use $p = 0.2$ to convert R_c in an absolute magnitude, leading to

$$M(1,1) \sim 1.9 + 2.5 \log r, \tag{7}$$

again with r in AU. This give $M(1,1) \sim 5$ at $r = 17$ AU, and 6 at 43 AU. In what follow, we will then take $M(1,1) = 5$ as a conservative limit, below which objects are likely to keep at least part of their atmosphere in the Centaur and TN regions, therefore to be potentially affected by different resurfacing processes. Clearly, that choice is partly arbitrary. We performed the following analysis with different cut-off values, leading to similar results.

In order to verify whether we were justified to separate the bright $M(1,1)$ objects from the others, we compared their colours and gradient with those of the faint objects. The Trojans were not considered in this test, whose results are summarized in Table 4

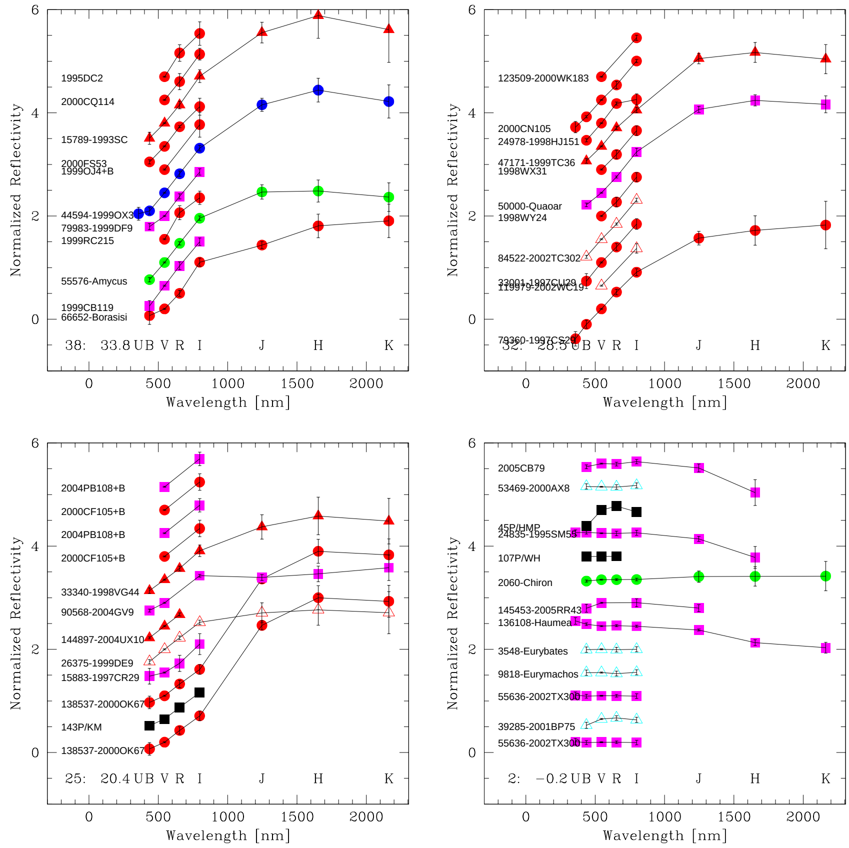


Fig. 3. Examples for reflectivity spectra for a set of objects. The reflectivity is normalized to unity for the V filter, and the spectra are shifted for clarity. The physico-dynamical class of the objects is identified by their symbols, which are explained in Fig. 2. The spectra for all the objects are available online on the MBOSS2 site.

With the exception of the $J-H$ colour, the bright and the faint objects have compatible mean colours and overall distribution. In the infrared, the bright objects have marginally bluer colour ($J-H = 0.27 \pm 0.25$) than the faint ones (($J-H = 0.41 \pm 0.20$); this has only a probability of 2.5% to occur by chance, i.e. this difference is marginally significant. Similarly, the bright objects have a slightly broader distribution of $H-K$ colour than the fainter ones (at the 3% level). When performing these tests on individual or group of classes, the result remains with a slightly stronger significance for the resonant objects, but cannot be tested on the other groups, which don't have enough bright objects. Nevertheless, removing the non-resonant objects increased the significance of the result for the resonant objects. Additionally, one must consider the possibility that the larger dispersion in $H-K$ for the fainter object is connected to the poorer signal-to-noise ratio in K, as the sky is much brighter in this band and the instruments tend to be less sensitive there.

Considering the colours of the various dynamical classes in the visible wavelength range for the bright ($M(1,1) < 5$) and faint objects, the colour distributions of the bright objects are undistinguishable from those of the fainter ones, indicating that the object populations might be rather uniform despite that some larger objects may differ in some surface properties (for instance albedo) and that intrinsic activity may play a role for resurfacing the bodies.

It is, however, noted that the near-IR colours of individual KBOs can differ from mean values if the surfaces are covered to a significant amount with ices that display strong absorptions (like CH_4), namely in H and K bands like Pluto, Eris and 2005 FY_9 (see Brown 2008). The presence of such ice absorptions can be inferred from an unusual negative slope for near-IR spectral gradients (i.e. from J to H and K bands).

In summary, the infrared colours of the objects with bright absolute magnitudes are slightly different than those of the fainter objects. We will therefore keep them separate for most colour tests, but we will also re-incorporate them for some tests on the visible colours where more objects are helpful.

Based on these results, one might consider to re-include the intrinsically brighter objects for the remainder of the study. However, we decided not to: If they are indeed similar, they would only marginally increase the size of the sample, not changing the conclusions. If they eventually turn out

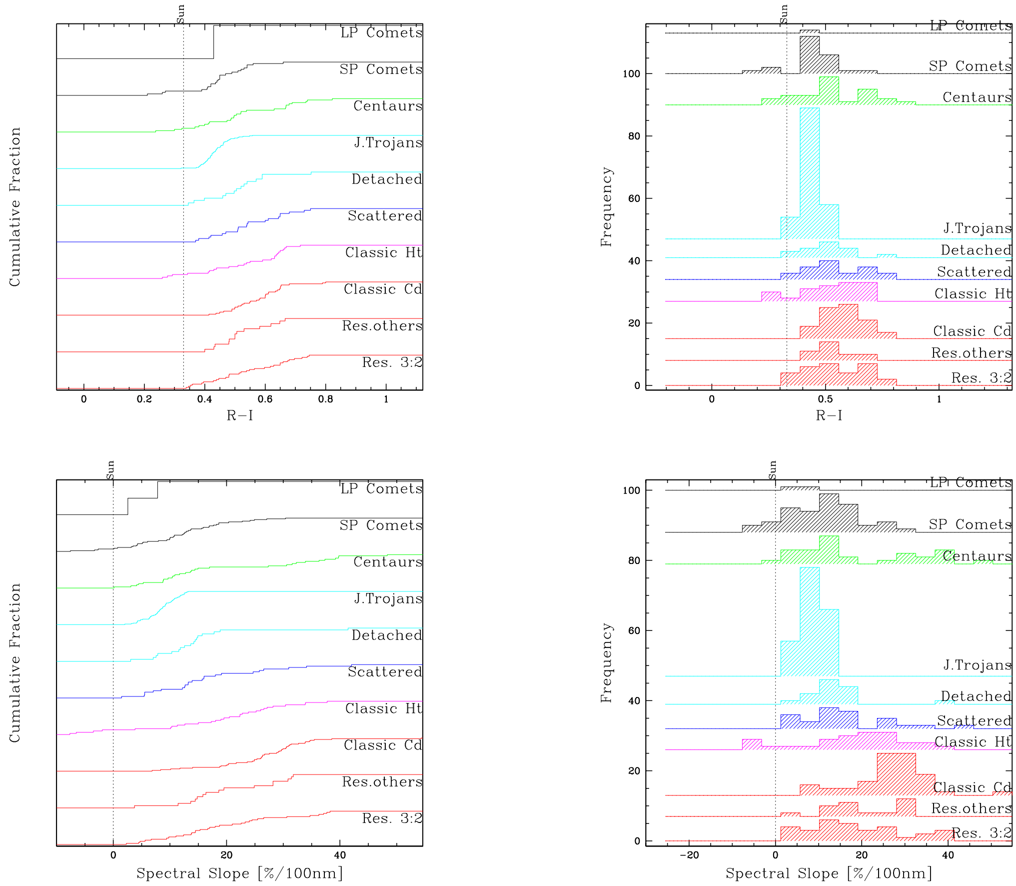


Fig. 4. $R-I$ (top) and spectral gradient (bottom) cumulative distributions (left) and histogram (right). Solar value is indicated by a dotted line. Similar plots are available on-line for the other colours.

to be different, as possibly suggested by the near-IR colours, we did the right thing keeping them separate.

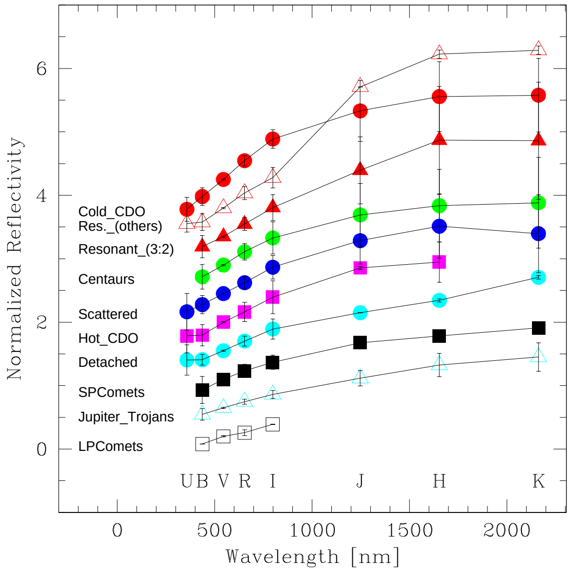
3.3. Global characteristics of individual classes

The MBOSS2 database that we analyze contains photometric measurements of 10 different dynamical classes (see Fig. 2), i.e. the short-periodic comets (SPC), the long-periodic comets (LPC), the Jupiter Trojans, Kuiper Belt objects in 3:2 (Plutinos = Res. 3:2) and in other orbital resonances (Res.others) with Neptune, the Classical Disk objects (CDOs) in two flavors as dynamically 'hot' and 'cold' CDOs, the Scattered Disk objects (SDOs) and the Detached Disk objects (DDOs).

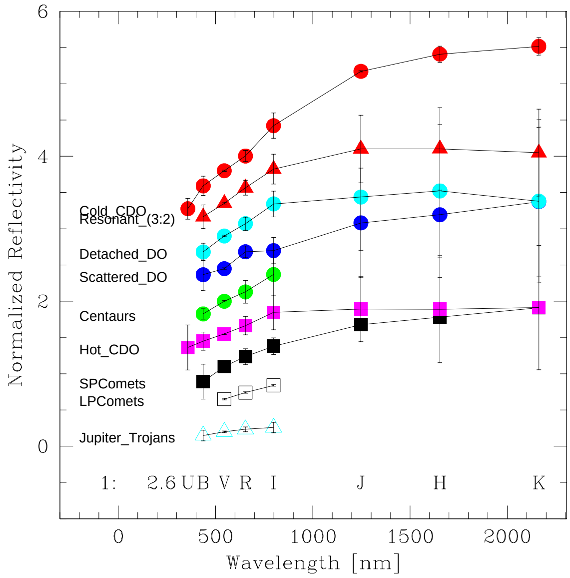
Selected colour-colour diagrams of MBOSSes are shown in Fig. 1. Colour distributions of the various classes of objects are displayed in Fig. 4, for a selection of colours and for the spectral gradient $\mathcal{S}$. At first sight, the ranges of visible colours are similar for the several dynamical groups (Plutinos and Resonants, CDOs, SDOs, Centaurs), ranging from slightly bluish (-10%/100 nm) compared to the Sun to very red (55%/100 nm). Jupiter Trojans do not appear to contain any very red objects (i.e. with spectral gradient > 20%/100 nm) as the other groups do. For LPCs the number of measured objects (14) may be too small to provide representative results for the total population, although it is noted that the available data indicate spectral gradients between about 0 and 10 %/100nm, well in agreement with the other groups.

The mean colours (and corresponding variances) for the various dynamical classes are listed in Table 7, top panel, using all data in the MBOSS2 database, and the values for the restricted dataset of objects with $M(1,1) \geq 5$ mag are in Table 7, bottom panel. Many of these means are based on only a small number of objects, and their general representative should be taken with care.

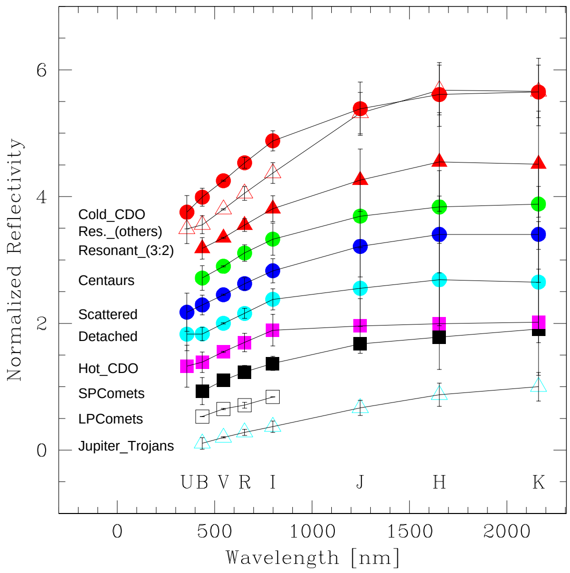
The average characteristics of the dynamical classes are also displayed as reflectivity spectra in Fig. 5. The red slope in the visible wavelength range, although different for individual groups, levels off in the near-IR with transition between I and J or H bands.



a



b



c

Fig. 5. Average reflectivity spectra for the different physico-dynamical classes. a: small objects ($M(1,1) > 5$ mag), b: large objects only ($M(1,1) < 5$ mag), c: all the objects

Table 5. Statistical comparisons of the spectral gradient distributions of pairs of MBOSS populations: t-test, f-test, KS test

			Resonant (Others)	Classical Cold	Classical Hot	Scattered Disk Objects	Detached Disk Objects	Centaurs	Short Period Comets	Long Period Comets	Trojans
N			15	43	28	23	17	26	44	0	60
Resonant	31	*t*	0.701	0.002	0.713	0.340	0.056	0.768	0.006		0.000
3:2		*f*	0.367	0.209	0.505	0.777	0.264	0.163	0.334		0.000
		KS	0.810	0.000	0.817	0.612	0.023	0.438	0.072		0.000
			Indist.	Not comp.	Indist.	Indist.	Marginal	Indist.	Marginal	-/-	Not comp.
Resonant	15	*t*		0.019	0.485	0.211	0.034	0.968	0.005		0.000
others		*f*	.	0.986	0.166	0.523	0.881	0.057	0.810		0.000
		KS		0.019	0.680	0.183	0.009	0.101	0.020		0.000
				Marginal	Indist.	Indist.	Marginal	Indist.	Marginal	-/-	Not comp.
Classical	43	*t*			0.002	0.000	0.000	0.038	0.000		0.000
Cold		*f*		.	0.051	0.402	0.839	0.006	0.747		0.000
		KS			0.006	0.000	0.000	0.000	0.000		0.000
						Not comp.	Not comp.	Not comp.	Not comp.	-/-	Not comp.
Classic	28	*t*				0.602	0.160	0.560	0.039		0.000
Hot		*f*			.	0.377	0.106	0.471	0.094		0.000
		KS				0.161	0.002	0.284	0.040		0.000
						Indist.	Marginal	Indist.	Marginal	-/-	Not comp.
Scattered	23	*t*					0.355	0.286	0.114		0.001
Disk		*f*				.	0.406	0.125	0.569		0.000
Objects		KS					0.280	0.358	0.359		0.000
							Indist.	Indist.	Indist.	-/-	Not comp.
Detached	17	*t*						0.064	0.583		0.020
Disk		*f*					.	0.031	0.662		0.000
Objects		KS						0.182	0.444		0.000
								Indist.	Indist.	-/-	Not comp.
Centaurs	26	*t*							0.015		0.000
		f						.	0.014		0.000
		KS							0.035		0.000
									Marginal	-/-	Not comp.
Short	44	*t*									0.090
Period		*f*						.			0.000
Comets		KS									0.000
										-/-	Not comp.

Notes: The three tests are the Student $t-$ and $f-$tests and the KS test. The number N indicate how many objects have measurements. The result is the probability that the two distributions are randomly extracted from the same population. The label indicates whether the populations are significantly different, marginally different, or statistically undistinguishable (see text for details).

3.4. Comparisons between classes

In the comparison of the photometric properties between the dynamical classes all groups are considered except long-periodic comets LPCs, since the number statistics of LPCs seems to be too sparse to expect firm conclusions.

3.4.1. Colours and spectral gradients

Comparing the colour distribution of the different physico-dynamical classes, it appears (see Fig. 4) that:

– The distributions of the colours and of the spectral gradients in the visible wavelength range differ among the groups, in extend, shape and peak location. Taking the spectral gradients as an example, the peak level increases starting with the Jupiter Trojans (5-10%/100 nm), over the SPCs, Centaurs, DDOs, SDOs, Plutinos (and possibly the resonant objects) (10-20%/100 nm), to the hot CDOs (20-30%/100 nm) and finally to the cold CDOs as the reddest objects (25-35%/100 nm) among the MBOSSes. Colour ranges and distribution width are well noticeable in the cumulative distribution functions (see left panels of Fig. 4).
– Relevant secondary peaks in the frequency distributions may exist for Centaurs and Plutinos at higher reddening. At least for Centaurs, statistical arguments for a bimodal surface colour distribution were presented in numerous papers (Tegler and Romanishin 1998, 2003; Peixinho et al. 2003; Delsanti et al. 2006; Tegler et al. 2008, eg). Tegler et al. (2008) presented a detailed analysis of the Centaurs' bimodality, based on a sample of 26 objects, ie almost as large as the

Table 6. Statistical comparisons of the $J-H$ colour distributions of pairs of MBOSS populations: t-test, f-test, KS test

			Classic cold	Classic hot	Centaurs
	N		28	34	17
Resonant 3:2	21	t	0.498	0.119	0.308
		f	0.000	0.961	0.000
		KS	0.449	0.677	0.984
			Not comp.	Indist.	Not comp.
Classic cold	28	t		0.121	0.332
		f	-	0.000	0.703
		KS		0.710	0.284
				Not comp.	Indist.
Classic hot	34	t			0.271
		f	-	-	0.000
		KS			0.499
					Not comp.

Notes: The three tests are the Student $t-$ and $f-$tests and the KS test. The N number indicate how many objects have measurements. The classes that are not listed do not have sufficiently measurements for these tests to be performed. The result is the probability that the two distributions are randomly extracted from the same population. The label indicates whether the populations are significantly different, marginally different, or statistically undistinguishable (see text for details).

one presented here (29 objects, so we do not present a new analysis). They conclude that the $B-R$ distribution is bimodal with a confidence level of 99.5%, with 10 red centaurs and 16 gray ones. The red ones have marginally smaller orbital inclinations, and higher albedo at the 99% confidence level.

– The frequency distribution in $J-H$ instead gives a rather uniform picture for all dynamical groups with respect to colour range and peak position (with a few singular exceptions for Plutinos and CDOs).

This global characterization indicates that parameters of the visible spectral energy distribution are better diagnostics for the global surface reflectivity and differences among MBOSSes compared to the near-IR colours. However, it is noted that near-IR spectral information of MBOSSes is more sensitive to specific and pronounced compositional differences than visible one, because stronger absorption bands, in particular of icy compounds, are found in the near-IR wavelength domain (Barucci et al. 2008).

Table 7. Mean colours, and variances, for the MBOSS populations: all objects

colour	Res. 3:2	Res.others	Classic cold	Classic hot	Scattered	Detached	J.Trojans	Centaurs	SP Comets	LP Comets
Full database										
$U-B$	0	2	3	11	7	2	0	0	0	0
	— —	0.273±0.090	0.593±0.123	0.258±0.168	0.334±0.144	0.180±0.156	— —	— —	— —	— —
$B-V$	38	16	41	38	27	22	74	28	17	1
	0.868±0.170	0.975±0.142	0.996±0.140	0.864±0.163	0.858±0.153	0.869±0.109	0.777±0.091	0.892±0.195	0.863±0.209	0.810±0.000
$V-R$	38	21	49	41	25	23	80	30	43	2
	0.558±0.101	0.603±0.109	0.630±0.086	0.510±0.145	0.536±0.096	0.519±0.083	0.445±0.048	0.567±0.131	0.494±0.105	0.422±0.045
$V-I$	40	23	73	51	28	24	80	26	22	1
	1.101±0.202	1.181±0.164	1.220±0.159	1.010±0.249	1.037±0.189	1.039±0.170	0.861±0.090	1.077±0.252	0.947±0.112	0.878±0.000
$V-J$	16	5	5	13	9	4	12	10	1	0
	1.838±0.493	2.138±0.327	1.960±0.421	1.509±0.431	1.753±0.481	1.614±0.601	1.551±0.120	1.769±0.498	1.630±0.000	— —
$R-I$	36	19	36	35	22	21	80	26	23	1
	0.536±0.122	0.554±0.090	0.588±0.095	0.506±0.139	0.544±0.108	0.515±0.099	0.416±0.057	0.525±0.151	0.447±0.101	0.430±0.000
$J-H$	21	13	28	34	13	10	12	17	1	0
	0.442±0.285	0.437±0.065	0.398±0.082	0.316±0.290	0.400±0.124	0.381±0.126	0.434±0.064	0.375±0.075	0.360±0.000	— —
$H-K$	11	4	4	8	8	4	12	15	1	0
	0.043±0.059	0.052±0.023	0.079±0.030	0.077±0.117	0.060±0.151	0.035±0.228	0.139±0.041	0.085±0.143	0.140±0.000	— —
Grt	45	25	82	56	29	26	80	30	43	2
	18.633±10.659	23.471±9.362	25.515±9.217	15.387±11.887	15.258±9.974	15.459±8.873	7.024±3.786	19.320±13.842	11.483±8.307	5.188±3.692
$M(1,1)$	38	21	46	45	24	23	60	29	134	13
	6.680±1.981	6.235±1.393	6.600±0.614	5.928±1.703	7.168±1.225	5.718±2.181	11.356±1.057	9.456±1.654	16.131±1.667	13.550±3.601

Table 7. Mean colours, and variances, for the MBOSS populations, continued: Objects with $M(1,1) > 5$mag

colour	Res. 3:2	Res.others	Classic cold	Classic hot	Scattered	Detached	J.Trojans	Centaurs	SP Comets	LP Comets
Objects with $M(1,1) \geq 5$ mag										
$U-B$	0	1	2	3	7	2	0	0	0	0
	——	0.210±0.000	0.525±0.049	0.187±0.103	0.334±0.144	0.180±0.156	——	——	——	——
$B-V$	26	10	34	22	23	15	60	28	16	1
	0.858±0.175	0.943±0.131	1.011±0.139	0.919±0.167	0.876±0.143	0.836±0.084	0.789±0.092	0.892±0.195	0.872±0.213	0.810±0.000
$V-R$	31	15	42	29	23	16	60	30	43	2
	0.555±0.102	0.590±0.102	0.642±0.082	0.523±0.152	0.532±0.098	0.513±0.077	0.461±0.040	0.567±0.131	0.494±0.105	0.422±0.045
$V-I$	31	13	37	25	22	15	60	26	22	1
	1.098±0.205	1.114±0.162	1.226±0.145	1.050±0.258	1.068±0.186	1.010±0.159	0.898±0.062	1.077±0.252	0.947±0.112	0.878±0.000
$V-J$	9	1	4	2	6	1	12	10	1	0
	1.912±0.528	2.295±0.000	1.932±0.480	1.807±0.024	1.796±0.369	1.646±0.000	1.551±0.120	1.769±0.498	1.630±0.000	——
$R-I$	30	13	33	25	20	14	60	26	23	1
	0.538±0.127	0.521±0.084	0.578±0.090	0.529±0.137	0.549±0.113	0.510±0.104	0.437±0.044	0.525±0.151	0.447±0.101	0.430±0.000
$J-H$	14	5	17	17	9	5	12	17	1	0
	0.518±0.319	0.467±0.064	0.401±0.071	0.342±0.296	0.417±0.133	0.414±0.026	0.434±0.064	0.375±0.075	0.360±0.000	——
$H-K$	6	1	3	0	5	1	12	15	1	0
	0.056±0.076	0.080±0.000	0.070±0.030	——	-0.004±0.114	0.260±0.000	0.139±0.041	0.085±0.143	0.140±0.000	——
Grt	31	15	43	28	23	17	60	30	43	2
	19.051±10.558	20.240±8.496	26.488±8.567	17.795±12.258	16.526±10.121	13.971±8.172	8.538±2.759	19.320±13.842	11.483±8.307	5.188±3.692
$M(1,1)$	32	15	45	34	23	17	60	29	134	13
	7.392±0.802	6.974±0.795	6.635±0.571	6.717±0.833	7.275±1.124	6.746±0.572	11.356±1.057	9.456±1.654	16.131±1.667	13.550±3.601

Notes: The number of objects included in each average is indicated. Grt is the spectral gradient $\mathcal{S}$. $M(1,1)$ is the R absolute magnitude.

We now want to compare populations using the statistical tests described in section 3.1. First of all, it must be stressed that a common feature among the statistical tests applied is to output a probability that the two populations compared are *not* randomly extracted from the same population. In other words, the statistical tests can very firmly establish that two populations are significantly different. A contrario, no statistical test can prove that two populations are identical. For instance, the colour distributions of the Centaurs and Jupiter Trojans (see Tab. 5) are radically different with a very high significance level: It is totally improbable that these two populations were randomly extracted from the same reservoir. However, the spectral gradient distributions of SDOs and DDOs indicate these objects could have been randomly extracted from a same pool — but it is absolutely possible that this is a coincidence.

Table 5 summarizes the results of the comparison between the spectral gradient S distribution of the MBOSS populations using these tests. Following the discussion in Section 3.2, the tests were restricted to the objects with $M(1,1) > 5$ mag. For each pair, the table lists the probabilities that the two classes were randomly extracted from a common population, based on the mean spectral gradient (t-test), the spectral gradient variance (f-test), and the overall spectral gradient distribution (KS test). Low probabilities indicate that the two considered distributions are not compatible. The pairs for which at least one of the tests returns a probability < 0.001 were flagged as not compatible, indicating they are significantly different. Those where a test indicates a probability < 0.05 are marked as marginally different, suggesting that there is a difference, but that it is not very strongly significant. The others are statistically undistinguishable using these tests. Again, it does not mean that the objects are similar, just that these tests cannot prove they are different. Similar tests were performed on the individual colours, with similar results. We discuss here only the spectral gradients, as it encompasses most of the information present in the visible spectrum range.

In the infrared, the tests are possible only in $J-H$, and only some of the classes have enough measurements for the tests to be meaningful. The results are presented in Table 6. The statistical tests indicate:

- The spectral gradient distributions of the various resonant classes are statistically indistinguishable. In order to increase the size of the sample, all the resonant objects are split only between Plutinos (3:2) and Other Resonant Objects.
- The spectral gradient distributions of Plutinos and other Resonant Objects, SDOs, hot CDOs, and Centaurs are indistinguishable,
- Additionally, the Plutinos and the hot CDOs had indistinguishable $J-H$ distributions.
- The spectral gradient distribution of DDOs is indistinguishable from that of SDOs and only marginally distinguishable from that of Plutinos and resonant objects, as well as hot CDOs.
- The spectral gradient distribution of cold CDOs is not compatible with the ones of hot CDOs, Plutinos, SDOs, DDOs and Centaurs, and it is only marginally compatible with that of the resonant objects.
- Additionally, the cold CDOs $J-H$ distribution is not compatible with that of the Plutinos and the hot CDOs.
- The spectral gradient distribution of Jupiter Trojans clearly indicates complete incompatibility with all other MBOSS populations.
- The spectral gradient distribution of SPCs is significantly different from that of the Jupiter Trojans and cold CDOs. It is only marginally different from that of the hot CDOs, Plutinos and other resonant objects as well as Centaurs, and it cannot be distinguished from that of SDOs, DDOs.
- The $J-H$ colours of the Centaurs is not compatible with those of the Plutinos and of the hot CDOs.

In conclusion: Plutinos, other Resonant Objects, hot CDOs, SDOs and DDOs may be rather similar for their spectral gradients in the visible, while cold CDOs and Jupiter Trojans form two separate groups for their spectral properties in the visible wavelength range. The peak in the spectral gradient distribution of hot CDOs seems to be shifted slightly to higher reddening, for the moment a suggestion not yet at statistical significance level. SPCs may agree with the first populations mentioned above.

3.4.2. Absolute magnitude

The absolute magnitude $M(1,1)$ of an object depends on the reflectivity function across the surface, i.e. in a first order approximation on the object size, the geometric albedo and the photometric phase function. Given the relationship between $M(1,1)$, size, albedo and phase function one can assume that the $M(1,1)$ distribution is dominated by the effects of the size, except for the largest bodies which often have high albedoes (Stansberry et al. 2008). The solar phase angle for KBOs is always

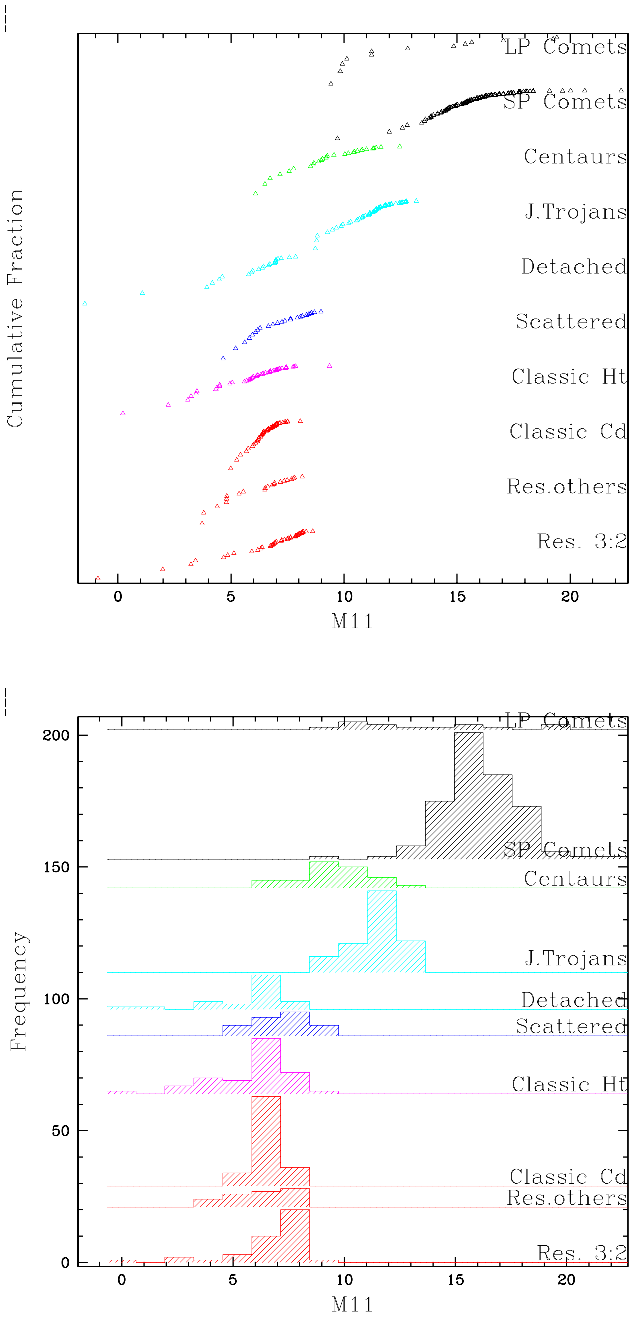


Fig. 6. *R* absolute magnitude $M(1, 1)$ cumulative distributions (logarithmic, left) and histogram (right).

relatively small, and the phase function is moderately steep, so the effect on $M(1, 1)$ hardly exceeds 0.2-0.3mag. Hence, we assume that the $M(1, 1)$ distribution of KBOs reflects –at least to zeroth order– the size distribution of the objects, with the understatement that a detailed analysis requires more accurate size estimates of the objects. Such a careful study can be found in Stansberry et al. (2008).

The $M(1, 1)$ distributions are strongly biased by cumulative selection effects: while there are few bright and large objects in a given class, they are more easy to discover, and also more easy to observe, so they are likely to be represented in this data set. A contrario, the discovery surveys are not complete for fainter objects, and faint objects are less likely to be picked by observers performing colour measurements. Consequently, the $M(1, 1)$ distributions are likely to be fairly complete at the bright end, but to have complex non-completeness at the faint end. Meech et al. (2004) discussed and simulated many of these selection effects.

Fig. 6 shows the frequency histogram and cumulative distribution function of $M(1,1)$ for the various MBOSS groups, now covering all objects in the MBOSS database (i.e. not excluding those with $M(1,1) > 5$ mag).

The selection bias against small KBOs is clear, with no object fainter than $M(1,1) \sim 8.5$ in the distant classes – this corresponds to actual magnitudes fainter than 23.5 for Plutinos, and even fainter for CDOs, i.e. about the limiting magnitude for colour observations performed with fairly short exposures on a 8 meter class telescope. On the other hand, Centaurs and SPCs may be seen as a sample of smaller KBOs that is scattered towards the inner planetary system. Meech et al. (2004) found that the shape of the short period comet size distribution is incompatible with that of the other TNOs.

The slope k of the logarithmic cumulative $M(1,1)$ distribution relates to the power law q of the cumulative radius distribution $N_c(a) \propto a^{-q}$ as $q = 5k$. Measuring the k slopes on the straight parts of the distributions in Fig. 6 leads to values $q \sim 0.8$ for the SPCs, the Centaurs, the SDOs, the DDOs, the hot CDOs and the Resonant objects; the steep slope of the cold CDOs and the DDOs corresponds to $q \sim 2$. Only the steepest part of the SP Comets distribution reaches $q \sim 3$. The analysis based on controled samples designed for size analysis lead to much steeper $q = 3.0$ (Trujillo et al. 2001) to 3.5 (Kenyon and Bromley 2004), i.e. much richer in small/faint objects. This confirms that the sample used for colour measurements is heavily biased against faint objects –only the brightest SPCs might be fairly complete.

Therefore, the size distributions in Fig. 6 should only be used for internal comparison, with the hope that the selection effects were affecting them in a similar way, and/or restricting the analysis to the bright end of the distributions.

Clearly, the observed Jupiter Trojans ($M(1,1)$ between 8 and 13 mag) are smaller than KBOs (that cover the $M(1,1)$ range from about 0 to 9 mag). The bulk of that shift corresponds to the fact that the geometry gives an advantage of ∼ 4 mag for the Trojans.

It is noteworthy that cold CDOs display a rather peaked $M(1,1)$ distribution and do not contain objects with $M(1,1)$ brighter than about 5 mag, while Plutinos, hot CDOs and DDOs contain objects of 2 to -1mag. The rather steep slope in the cumulative distribution function of $M(1,1)$ of the cold CDOSs reflects the likely difference in the size range of these KBOs. In particular, it is different from that of hot CDOs which should be exposed to very similar selection effects, i.e. it is real. The brightest resonant objects reach $M(1,1)$ of about 3mag, while the SDOs are more of the brightness of cold CDOs, however with a much less pronounced peak level on a bit wider distribution plateau.

From the $M(1,1)$ distributions of MBOSSes we conclude that the absence of larger bodies among the cold CDOs and their presence among other populations of the Kuiper Belt may suggest different formation environments for both groups of objects that may have favored the growth of larger bodies for Plutinos, SDOs, DDOs and possibly hot CDOs compared to cold CDOs. Jupiter Trojans are a population of smaller size bodies, again arguing for a formation environment and evolution scenario that were distinct from that of the other MBOSSes (now including cold CDOs). Since it is very likely that the large bodies in these groups may have survived impact events widely unaffected for their sizes over the lifetime of the Solar System, one can assume that they represent the original population of planetesimals. The Centaurs reach the magnitude/size range where the vast majority of larger KBOs are detected, but they do not include one of the rare big ones. This might well be compatible with the scattering scenario for Centaurs but needs quantitive confirmation by dynamical calculations.

Altogether, the $M(1,1)$ distributions give the impression that the MBOSSes may have been formed in at least 3 (maybe 4) different environments, i.e. one for the Jupiter Trojans, one for the cold CDOs, maybe one for the hot CDOs and one for the rest of the bodies. Since KBOs are now and were for very long time residing in the same distance range, one may consider Plutinos, resonant objects, hot CDOs, and SDOs as immigrant population of the Kuiper Belt compared to the cold CDOs that may represent "aborigines KBOs". Interestingly, also the DDOs appear to be 'sizewise' in accord with the Kuiper Belt "immigrants", although they are found in a much more distant location.

3.5. Dependencies with dynamical parameters

The colour distribution (say, the $B - V$ distribution) of a class of objects (say, the Centaurs) is considered as a function of another parameter of the objects (say, the perihelion distance q) to search for correlations as possible indicators for physical dependencies. The traditional Pearson correlation factor is not robust for non-linear dependencies, so a simpler and more robust estimator was used: The sample is divided in two sub-samples, using the median value of the independent variable (in the example, the median q of the Centaurs, i.e. 16.22 AU). The colour distribution

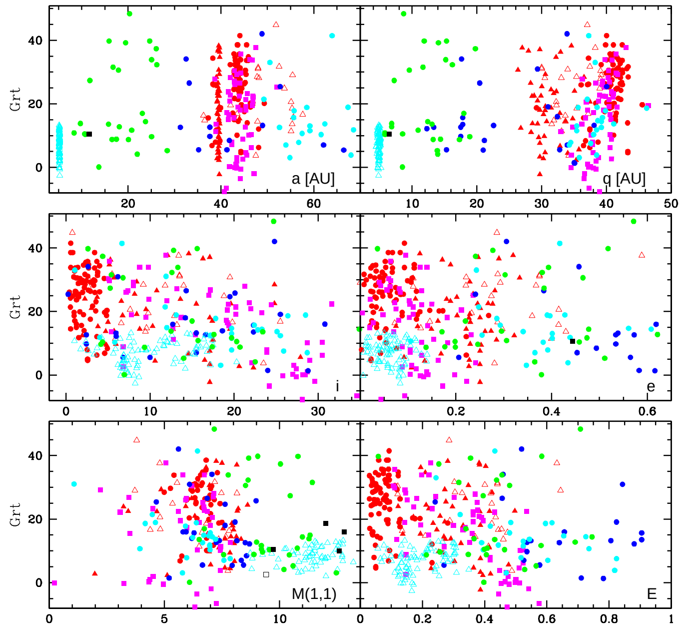


Fig. 7. The spectral gradient $\mathcal{S}$ of the objects [%/100 nm] as a function of the main orbital elements, and of the orbital excitation $\mathcal{E}$ and the absolute R magnitude $M(1,1)$. Similar plots are available on-line for the various colours.

Table 8. Averge colour and dispersion for the cold CDOs, comparing those with smaller a (or q) with those with large values.

Colour	N	Aver./σ	N	Aver./σ	$t-Prob$	$f-Prob$
		$a < 43.95$		$a \leq 43.95$		
$B-V$	16	0.99±0.16	18	1.03±0.11	0.148	0.148
$B-R$	16	1.59±0.26	17	1.69±0.09	0.151	0.000
$B-I$	9	2.18±0.37	14	2.27±0.15	0.489	0.003
$V-R$	21	0.63±0.10	21	0.65±0.06	0.310	0.034
$V-I$	17	1.20±0.16	20	1.24±0.14	0.395	0.538
		$q < 40.91$		$q \leq 40.91$		
$B-V$	17	0.95±0.17	17	1.07±0.06	0.013	0.000
$B-R$	16	1.56±0.25	17	1.72±0.07	0.024	0.000
$B-I$	13	2.15±0.30	10	2.34±0.13	0.060	0.017
$V-R$	19	0.61±0.08	23	0.67±0.08	0.033	0.802
$V-I$	18	1.20±0.18	19	1.25±0.10	0.278	0.010

Notes: The a and q cut-off are set at the median value; N is the number of measurements; $t-Prob$ and $f-Prob$ are the probabilities that the two sub-samples are randomly extracted from the same distibution, evaluated with the $t-$ and $f-$tests. The other colours show insignificant differences.

of the two sub-samples are then compared through t-test and f-test and the Pearson correlation parameter is also estimated. Visually, this can be done by comparing the left-hand side with the right-hand side of all the sub-panels of Figure 7.

For cold CDOs: The variances of colours $B-V$, $B-R$ and $B-I$ are different for the inner (smaller variance) and the outer (larger variance) population among the cold CDOs (considering both their semi-major axis and perihelion distance). These differences have a good level of significance, as listed in Tab. 8. The effect is only marginally observed in $V-R$ and $V-I$. The average colours of the sub-samples are undistinguishable: only the breaths of the distributions are different

Since similar results are not found in other colours nor for the spectral gradients in the visible, it might be related with a wavelength dependent phenomenon that is mostly restricted to the B filter, like for instance a stronger unknown continuum absorber in the outer cold CDOs.

For hot CDOs: Hot CDOs with a perihelion closer to the Sun are significantly bluer than the ones that do not get close, ee Tab. 9 . This result is visible in the $B-V$, $B-R$ and $B-I$ colours (eg

Table 9. Averge colour and dispersion for the hot CDO, comparing those with smaller q with those with large values.

Colour	N	Aver./σ $q < 39.39$	N	Aver./σ $q \leq 39.39$	$t - Prob$	$f - Prob$
$B - V$	10	0.80±0.12	12	1.02±0.13	0.000	0.795
$B - R$	10	1.28±0.21	12	1.64±0.18	0.000	0.666
$B - I$	8	1.71±0.28	9	2.37±0.27	0.001	0.838
$V - R$	14	0.47±0.14	15	0.57±0.15	0.071	0.792
$V - I$	12	0.94±0.24	13	1.15±0.24	0.037	0.967

Notes: The q cut-off is set at the median value; N is the number of measurements; $t - Prob$ and $f - Prob$ are the probabilities that the two sub-samples are randomly extracted from the same distibution, evaluated with the $t-$ and $f-$tests. The other colours show insignificant differences.

Table 10. Averge colour and dispersion for the hot CDOs, comparing those with smaller i with those with large values.

Colour	N	Aver./σ $i < 17.0$	N	Aver./σ $i \leq 17.0$	$t - Prob$	$f - Prob$
$B - V$	14	0.99±0.16	8	0.80±0.09	0.002	0.096
$B - R$	14	1.60±0.21	8	1.26±0.20	0.002	0.940
$B - I$	11	2.14±0.33	6	1.70±0.31	0.020	0.978
$V - R$	15	0.61±0.08	14	0.43±0.16	0.001	0.012
$V - I$	13	1.20±0.15	12	0.89±0.26	0.002	0.064
Grad.	15	24.59±7.99	13	9.95±11.80	0.001	0.165

Notes: The q cut-off is set at the median value; N is the number of measurements; $t - Prob$ and $f - Prob$ are the probabilities that the two sub-samples are randomly extracted from the same distibution, evaluated with the $t-$ and $f-$tests. The other colours show insignificant differences.

$B - V = 0.80 \pm 0.12$ for $q < 39.4$ AU, and $B - V = 1.02 \pm 0.13$ mag for the others). This result is based on fairly small samples, which decreases the strength of its significance.

Hot CDOs with high inclinations or with large orbital excitation parameter are bluer than the others, see Tab. 10, a finding seen for several colours ($B-V$, $B-R$, $V-R$, $V-I$) as well as for the spectral gradient in the visible. The sample sizes are small, but sufficient. This result was already known (Trujillo and Brown 2002; Doressoundiram et al. 2008) and is generally expressed as anti-correlation between reddening of the objects and their orbital energy $\mathcal{E}$. The usual interpretation scenario is colour changes due to resurfacing by impact ejecta if during a collision between a hot CDO and another KBO subsurface material with different colour properties is ejected and deposited on the surface by impact excavations. Since cold CDOs do not display such an anti-correlation despite the fact that they occupy the same distance range as the hot CDOs do, it may be more an effect due to orbital energy, i.e. collision energy rather than collision frequency.

For others: Other combinations of dynamical parameters and colours, spectral gradient and $M(1,1)$ data of different dynamical classes do not show any statistically significant signal indicating possible correlations and physical dependencies.

3.6. Absolute magnitude

3.6.1. Absolute magnitude vs orbital parametres

For the comparison between $M(1,1)$ and dynamical parameters we consider the small objects ($M(1,1) \geq 5$ mag) only and we find:

For Centaurs, SDOs and DDOs, when considered together, objects with small semi-major axis a and perihelion distance q display a significantly fainter absolute magnitude $M(1,1)$ than the distant ones. While this is a statistically strong result, it disappears when the three classes are considered separately. Thus, it can simply be seen as the selection bias which makes the more distant and thus fainter objects harder to measure than the closer ones.

3.6.2. Absolute magnitude of the blue objects, vs red objects:

Next, we compare the absolute magnitude $M(1,1)$ distribution of a class of objects in function of their colour, in order to explore whether the redder objects have the same $M(1,1)$ distribution as the bluer objects. Considering only the small objects ($M(1,1) \geq 5$ mag), the blue hot CDOs and the

Table 11. Averge $M(1,1)$ and dispersions for the hot CDOs, comparing those with blue vs red colours.

Colour	Colour cut-off	N	Aver./σ Blue	N	Aver./σ Red	$t-Prob$
hot TNOs						
$B-V$	0.92	11	6.92±0.67	11	6.54±0.62	0.183
$B-R$	1.55	11	7.09±0.45	11	6.37±0.64	0.007
$B-I$	1.92	8	7.13±0.52	9	6.41±0.67	0.025
$V-R$	0.56	14	6.88±0.61	15	6.34±0.62	0.026
$V-I$	1.10	12	6.87±0.61	13	6.29±0.65	0.031
$R-I$	0.54	12	6.85±0.53	13	6.30±0.72	0.039
Resonant Objects						
$B-V$	0.88	18	7.61± 0.81	18	6.79± 0.78	0.004
$B-R$	1.40	18	7.61± 0.81	18	6.79± 0.78	0.004
$B-I$	1.89	15	7.40± 0.84	16	6.79± 0.81	0.052
$V-R$	0.56	23	7.48± 0.72	23	7.04± 0.88	0.073
$V-I$	1.06	22	7.42± 0.72	22	7.08± 0.91	0.170
$R-I$	0.51	21	7.47± 0.78	22	7.01± 0.83	0.065

Notes: The objects with $M(1,1) < 5$ were excluded from this test; the colour cut-off is set at the median value for the considered colour; N is the number of measurements; $t-Prob$ are the probabilities that the two sub-samples are randomly extracted from the same distibution, evaluated with the $t-$test. The other colours show insignificant differences.

blue Resonant Objects have fainter absolute magnitudes than the redder objects of the same type (see Tab. 11).

3.6.3. Others Parameters

Other combinations of the absolute magnitude with other parameters do not show any statistically significant signal.

4. Interpretation scenarios

In the following discussion we try to elaborate and understand the results from the statistical analysis described in Section 3 in the framework of two rather different scenarios, i.e. surface colouration by on-going external processes and surface colours as a result from the primordial constitution of the bodies.

4.1. Surface colouration by external processes

Colour diversity of MBOSSes was originally attributed to the action of external processes on their surfaces. These process included: resurfacing by impacts, expected to produce neutral-bluish colours due to fresh ice excavated and spread over the surface, and an irradiation process, producing red colours via radiation aging (eg Luu and Jewitt 1996, for a model). When restricting our MBOSS database samples to objects with $M(1,1) \geq 5$ mag, as done during most of our analysis, a third process, i.e. resurfacing due to atmospheric deposits of material from intrinsic activity, is considered less important for the subsequent discussion, since it should affect large size bodies only, the smaller ones losing the material into space

A critical argument for significant changes in the surface reflectivity due to impacts comes from lightcurve analysis of MBOSSes: asymmetric or partial impact resurfacing of the body surfaces should cause colour variegations over rotation phase of the bodies that are, however, usually not seen (Sekiguchi et al. 2002, S. Sonnett, priv. comm., J. L. Ortiz, priv. comm.,) However, other authors report colour changes with rotation phase, eg for Haumea (Lacerda et al. 2008). So, strong variegation is certainly not wide-spread.

In the colouration scenario due to external processes DDOs are expected to represent the end state of radiation reddening of the surface, since one can assume that, for these objects, impact resurfacing is not happening at a significant level, simply because spatial number density of DDOs seems very low and collisions should therefore happen extremely rarely over the lifetime of the Solar System. From our statistical analysis we find that DDOs are not the reddest objects among MBOSSes. Instead cold CDOs show by far the reddest surface colours. In order to explain the smaller reddening of DDOs in this colouring scenario one has to assume that cold CDOs are not representing the end state of radiation reddening (despite showing the reddest colours), but high radiation doses, as collected by DDOs, decrease the spectral gradients again. Laboratory experiments (de Bergh et al. 2008) have found materials that display such a behaviour although the end state of the material shows rather neutral spectral gradients in the visible wavelength range. However, it remains open whether such materials exist in DDOs and, if not, whether the laboratory results apply more generally to more or even all possible surface compounds considered to exist in DDOs. It is also noteworthy to mention the coincidence of the peaks in the spectral gradient distributions of DDOs and for instance SDOs, Plutinos and resonant objects as well as Centaurs; this may be by chance despite the different importance of collisional resurfacing for these groups.

The colour cascade, with peaks in the colour histograms decreasing in reddening from cold CDOs over hot CDOs, to SDOs, Plutinos, resonant objects and parts of the Centaurs must be attributed to increasing importance of impact resurfacing. However, Centaurs live in a rather empty zone of the planetary system; hence, impact resurfacing must contribute less to their evolution. Here, the peak in the spectral gradient diagram could be attributed to resurfacing from intrinsic activity. Instead, the very red Centaurs represent the inactive objects that are subject to radiation reddening only, though not with extremely high doses (otherwise they could be expected to show similar reddening as DDOs). Currently, over the 6 known Centaurs showing cometary activity, only one has red colours. A larger sample of colours of cometary active Centaurs is therefore needed.

Jupiter Trojans differ in their surface reddening from the MBOSSes. It is remarkable, that Jupiter Trojans do not show very 'red' surfaces like objects in all MBOSS populations do, despite higher radiation doses from the Sun (due to their closer distance; factor of about 100). So, we conclude that this difference may be due to different material properties compared to MBOSSes.

An interesting behaviour is seen for the SPCs: Here, the population peak is well in the range of those for SDOs, Plutinos, moderately red Centaurs as well as for DDOs. Impact resurfacing should be negligible for SPCs and instead resurfacing due to activity could be the explaining reason. On the other side, due to the fast, continuous mass loss on short time scales (lifetime for active SPCs is estimated to be 100 000 years and less) the surface deposits should represent the intrinsic colour of the cometary material. Radiation aging is unimportant over the lifetime of SPC nuclei in the inner planetary system since cometary activity will result in fast and continuous resurfacing of the body. Hence, SPCs give the impression that their nuclei may consist –on a global scale– of material with rather homogeneous colour properties. As SPCs to a large extend originate from the Kuiper Belt (Gomes et al. 2008; Morbidelli et al. 2008) and because of their colour similarity to the immediate dynamical relatives therein (SDOs, Plutinos) and to the Centaurs from where SPCs are captured, it is attractive to assume that also the colours of these relatives should be globally uniform throughout the bodies. Jewitt (2002a) discusses the missing very red SPCs, suggesting that the red surfaces are rapidly buried while water ice sublimation starts at $r < 6$ AU.

4.2. Global colouration in the formation era

An alternative interpretation for the global findings on colour distributions and the $M(1,1)$ histogram of MBOSSes results from the scenario that the measured colours reflect global properties that apply for the material throughout the bodies. The motivation for this hypothesis comes from the interpretation of SPC colours and from the similarities of the peaks in the colour distribution of the MBOSS populations. We note that Brown et al. (2011) have recently introduced a similar hypothesis for the colour diversity among Kuiper Belt objects on the background of sublimation properties of supervolatile ices. What is described below can in parts be seen as arguments in support of such a 'primordial' colouration scheme for MBOSSes in the planetary system. 'Primordial' addresses the implicit assumption that the colours of the body materials are original from the time before the body was formed, i.e. they range back to the formation period of the planetary system and remained widely unaltered ever since.

An additional assumption of the hypothesis is that the surface materials are not - or at least not by a large amount - affected by external processes like reddening due to cosmic radiation. The global character of the material colours implies also that impact resurfacing would reproduce the original pre-impact surface colours of the bodies and large-scale colour diversities on the surface should not occur. Intrinsic activity in MBOSSes will expel gaseous species and solids of which at least the solids may resemble the original colours while the gases, if not lost to interplanetary space, may condense on the body as surface frost, in which case the surface colour may change. However, our selection criterion to use only objects with $M(1,1) > 5$ mag for the statistical analysis should significantly reduce the possibility that MBOSSes that may display intrinsic activity 'contaminate' the study results.

On the background of the primordial colouration scenario, the findings from our statistical analysis of the MBOSS colours allow interesting conclusions:

– At least 4 different colour populations may have existed in the protoplanetary disk, i.e. the cold CDOs, the hot CDOs, the SDO/DDO/Plutino population and the Jupiter Trojans. The four

populations are characterize by different surface colours and spectral gradients of decreasing amplitude in the visible wavelength region, but may have very similar colours in the near-IR.
- The colour diversities among MBOSS populations with different surface colours call for formation environments at different and disjunct distances from the Sun. Migration transport may have shifted the original populations to their current locations in the planetary system. Namely, migration may have placed cold and hot CDOs in the same distance range. Various papers have studied the dynamical aspects of such a migration process in the planetary system (Morbidelli et al. 2008). However, DDOs may represent a challenge for migration scenarios, in particular if one wants to include the aspects of colour similarities with other MBOSS populations.
- Similar colour properties among MBOSS populations at different locations in the outer planetary system may indicate a common formation region of the bodies. If so, it could apply for Plutinos and DDOs, objects nowadays found at rather different distances from the Sun. Again, migration (for the Plutinos) and scattering (for the DDOs) may have been involved in separating the bodies formed in a common source region.
- The migration and scattering processes have kept population of the same formation origin together and shifted them to confined destination regions with no obvious signs of intermixing from other sides. This conclusion suggests that the migration and scattering processes in the outer Solar System may not have had a very violent nature since they kept colour characteristics as population entities.
- The colour distributions for the populations with 'temporary' dynamical object association, i.e. SDOs, Centaurs, and SPCs, should reflect the efficiency of the injection and ejection processes of bodies from the various feeding populations, i.e. Plutinos, hot and cold CDOs.

There are supportive and also critical arguments from the statistical analysis for the conclusions above. In particular, the similarities and differences in the $M(1,1)$ distributions provide compatible evidences: The disjunct $M(1,1)$ distributions of the Jupiter Trojans and of the hot and cold CDOs (Doressoundiram et al. 2008, the latter is already noted in various papers and summarized in) may call for different formation environments at different solar distances. On the other side, the existence of large objects with $M(1,1) < 3$ mag among Plutinos and DDOs could be seen as a supportive argument for a common source region. Despite a possibly different formation environment for Plutinos and DDOs on one side and of the hot CDOs on the other side as suggested by their colour differences, the presence of large objects ($M(1,1) < 3$ mag) in all three populations suggests that the planetesimal formation and destruction processes were similarly efficient. On the other side, no obvious explanation - except an ad-hoc assumption as an outcome from the formation - can be offered for the anti-correlation between surface colours and excitation parameter as well as inclination among the hot CDO population, since the migration process should be 'colour-blind'. While the existence of very red objects among hot CDOs, DDOs, and Plutinos could be attributed to contaminations from the cold CDOs, the presence of bodies with blue and neutral surface in all populations except for cold CDOs and DDOs may call for colour contaminants either from the primordial environment or due to dynamical injection during a later phase.

5. A summarizing discussion

The MBOSS database first published in 2003 was updated using magnitude and colour measurements of TNOs, Centaurs, Jupiter Trojans, short- and long- periodic comets published since. A qualifying criterion was applied to the data in the database in order to distinguish 'problematic' measurement sets from more consistent ones. A new statistical analysis of the qualified colours, spectral gradient and absolute R magnitudes $M(1,1)$ data in the database was performed with the aim to identify group properties among the various dynamical MBOSS populations, i.e. for the hot and cold classical disk objects (CDOs), the scattered disk objects (SDOs), the Plutinos and resonant objects, as well as for related objects outside of the Kuiper belt like detached disk objects (DDOs), Centaurs, and short-periodic comets (SPCs), using a classification based on the SSBN08 system Gladman et al. (2008). Furthermore Jupiter Trojans are included in the analysis since, from all that is known, these objects are unrelated to the MBOSSes although representing an abundant population at the border of this region in the Solar System. In order to avoid or at least to reduce impacts on the surface colours due to intrinsic activity, the statistical sample was restricted to objects with normalized (but not yet phase corrected) brightness $M(1,1) \geq 5$ mag.

Our statistical analysis shows indications for indistinguishable and incompatible colour distributions and for differences and similarities in the $M(1,1)$ parameters among the MBOSS populations. These results suggest a scheme of 4 different colour (and $M(1,1)$) groups in the MBOSS regime, i.e. (1) cold CDOs, (2) hot CDOs, (3) Plutinos, resonant objects, SDOs, DDOs, Centaurs and SPCs, and (4) Jupiter Trojans. Additional correlations between photometric and dynamical parameters of the various populations were searched for, but only a single well-established one is found in the data of the hot CDOs (colour anti-correlates with inclination and collision energy parameter).

The statistical results are discussed on the background of two basic interpretation scenarios, i.e. explaining the surface colours of the MBOSSes (1) as being due to the interplay of resurfacing of impact ejecta (blue colour shift) and radiation reddening (red colour shift) and (2) as being of primordial nature imposed by the material properties of the formation environment. The two scenarios have the principle capability to explain our findings from the analysis of the MBOSS database. However, they are also challenged, each of them in a different way. The resurfacing scenario has to work out whether and under which assumption it is able to reproduce the actually observed colour, spectral gradient and $M(1,1)$ distributions of the MBOSSes and in particular that it can explain the reddening of the DDOs in this picture. To this respect, further lab measurements on the radiation reddening of reference materials under high dose levels can play an important role.

The primordial surface colour scenario has a strong argument in the apparent uniformity of surface colours among SPCs despite cometary activity should be able to excavate material layers of different colours if they exist throughout the nuclei. The primordial surface colour scenario works with ad hoc assumptions in the interpretation of colour, spectral gradient and $M(1,1)$ parameter distributions which require supportive justifications. Brown et al. (2011) have indicated some first arguments to this respect. However, beyond that the scenario interpretation relies on object migration for the transport of the MBOSSes from their formation environment to the various regions where they are found today. Object migration in the early planetary system was already introduced to explain the existence of the hot CDOs in the immediate neighborhood of the cold CDOs in the Kuiper Belt (for a review see Morbidelli et al., 2008). The primordial colouration scenario requires more than the shift of one or both CDO populations; it also asks for a detailed understanding of the dynamical processes and to which extend they may have affected the distribution of the measurements of the physical and surface parameters of the MBOSSes.

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Appendix A: Online material

Table A.1. Object class and colour data

Object	Class(1)	Epochs(2)	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
1P/Halley	SP Comet	2	13.558 ± 0.596	4.266 ± 2.015	0.720 ± 0.040	0.410 ± 0.030	0.390 ± 0.060	—	—	—
2P/Encke	SP Comet	6	15.207 ± 0.596	5.117 ± 2.574	0.780 ± 0.020	0.424 ± 0.053	0.408 ± 0.060	—	—	—
4P/Faye	SP Comet	2	16.020 ± 0.009	7.951 ± 0.000	—	0.450 ± 0.040	—	—	—	—
6P/dArrest	SP Comet	3	16.239 ± 0.009	13.264 ± 2.147	0.770 ± 0.040	0.563 ± 0.067	0.450 ± 0.040	—	—	—
7P/PW	SP Comet	2	15.185 ± 0.009	4.264 ± 2.620	—	0.400 ± 0.050	0.410 ± 0.060	—	—	—
8P/Tuttle	SP Comet	2	12.799 ± 0.009	15.869 ± 2.326	0.890 ± 0.040	0.530 ± 0.040	0.530 ± 0.060	—	—	—
9P/Tempel 1	SP Comet	14	14.560 ± 0.460	9.959 ± 0.826	—	0.468 ± 0.010	0.469 ± 0.013	—	—	—
10P/Tempel 2	SP Comet	10	14.287 ± 0.304	13.740 ± 1.578	0.800 ± 0.020	0.521 ± 0.037	0.520 ± 0.030	—	—	—
14P/Wolf	SP Comet	2	15.423 ± 0.009	17.666 ± 3.210	—	0.570 ± 0.070	0.510 ± 0.060	—	—	—
15P/Finlay	SP Comet	1	17.488 ± 0.009	—	—	—	—	—	—	—
16P/Brooks2	SP Comet	1	16.107 ± 0.009	—	—	—	—	—	—	—
17P/Holmes	SP Comet	2	16.094 ± 0.009	18.608 ± 0.000	—	0.560 ± 0.020	—	—	—	—
19P/Borrelly	SP Comet	1	15.860 ± 0.009	—	—	—	—	—	—	—
21P/GZ	SP Comet	2	17.259 ± 0.009	12.661 ± 2.057	0.800 ± 0.030	0.500 ± 0.020	—	—	—	—
22P/Kopff	SP Comet	4	16.093 ± 0.156	12.577 ± 2.730	0.795 ± 0.056	0.519 ± 0.046	0.450 ± 0.055	—	—	—
24P/Schaumasse	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
26P/GS	SP Comet	2	16.642 ± 0.136	5.227 ± 0.000	—	0.420 ± 0.139	—	—	—	—
28P/Neujmin1	SP Comet	11	12.580 ± 0.009	9.967 ± 4.007	—	0.494 ± 0.072	0.440 ± 0.079	—	—	—
29P/SW1	Centaurs	3	11.322 ± 0.009	14.948 ± 1.099	0.790 ± 0.030	0.536 ± 0.030	0.497 ± 0.025	—	—	—
30P/Reinmuth1	SP Comet	1	14.602 ± 0.009	—	—	—	—	—	—	—
31P/SW2	SP Comet	1	14.803 ± 0.009	—	—	—	—	—	—	—
32P/ComasSola	SP Comet	1	14.478 ± 0.009	—	—	—	—	—	—	—
33P/Daniel	SP Comet	1	17.053 ± 0.009	—	—	—	—	—	—	—
36P/Whipple	SP Comet	1	15.432 ± 0.009	—	—	—	—	—	—	—
37P/Forbes	SP Comet	2	17.348 ± 0.009	3.181 ± 2.015	—	0.290 ± 0.030	0.660 ± 0.060	—	—	—
39P/Oterma	Centaurs	3	12.464 ± 0.009	3.094 ± 3.964	0.890 ± 0.070	0.386 ± 0.063	0.412 ± 0.114	—	—	—
40P/Vaisala1	SP Comet	1	15.983 ± 0.009	—	—	—	—	—	—	—
41P/TG	SP Comet	1	18.034 ± 0.009	—	—	—	—	—	—	—
42P/Neujmin3	SP Comet	1	17.259 ± 0.009	—	—	—	—	—	—	—
43P/WH	SP Comet	1	15.983 ± 0.009	—	—	—	—	—	—	—
44P/Reinmuth2	SP Comet	2	16.225 ± 0.009	24.892 ± 0.000	—	0.620 ± 0.080	—	—	—	—
45P/HMP	SP Comet	2	17.744 ± 0.009	0.768 ± 2.444	1.080 ± 0.050	0.440 ± 0.050	0.210 ± 0.050	—	—	—
46P/Wirtanen	SP Comet	3	18.369 ± 0.009	4.079 ± 0.000	—	0.407 ± 0.081	—	—	—	—
47P/AJ	SP Comet	2	15.024 ± 0.009	3.454 ± 7.417	0.780 ± 0.080	0.400 ± 0.080	—	—	—	—
48P/Johnson	SP Comet	1	14.970 ± 0.009	—	—	—	—	—	—	—

Table A.1. continued.

Object	Class[1]	Epochs[2]	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
49P/AR	SP Comet	3	14.120 ± 0.277	9.452 ± 2.141	0.770 ± 0.030	0.471 ± 0.032	0.444 ± 0.064	1.630 ± 0.200	0.360 ± 0.141	0.140 ± 0.141
50P/Arend	SP Comet	2	17.371 ± 0.009	24.132 ± 4.627	—	0.810 ± 0.100	0.260 ± 0.090	—	—	—
51P/Harrington	SP Comet	1	15.648 ± 0.009	—	—	—	—	—	—	—
52P/HA	SP Comet	1	16.690 ± 0.009	—	—	—	—	—	—	—
53P/VanBiesbroec	SP Comet	2	14.647 ± 0.009	-2.672 ± 0.000	—	0.328 ± 0.081	—	—	—	—
55P/TT	SP Comet	2	15.543 ± 0.482	10.765 ± 2.444	0.750 ± 0.050	0.510 ± 0.050	0.420 ± 0.050	—	—	—
56P/SB	SP Comet	1	16.294 ± 0.009	—	—	—	—	—	—	—
57P/dTND	SP Comet	1	16.239 ± 0.009	—	—	—	—	—	—	—
58P/JN	SP Comet	1	18.369 ± 0.009	—	—	—	—	—	—	—
59P/KK	SP Comet	2	17.771 ± 0.009	12.937 ± 3.558	—	0.620 ± 0.070	0.270 ± 0.080	—	—	—
60P/Tsuchinshan2	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
61P/SS	SP Comet	1	18.229 ± 0.009	—	—	—	—	—	—	—
62P/Tsuchinshan1	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
63P/Wild1	SP Comet	2	16.453 ± 0.009	10.054 ± 2.273	—	0.500 ± 0.050	0.420 ± 0.040	—	—	—
64P/SG	SP Comet	1	16.239 ± 0.009	—	—	—	—	—	—	—
65P/Gunn	SP Comet	1	13.853 ± 0.009	—	—	—	—	—	—	—
67P/CG	SP Comet	2	15.754 ± 0.009	13.630 ± 0.000	—	0.510 ± 0.060	—	—	—	—
68P/Klemola	SP Comet	1	15.547 ± 0.009	—	—	—	—	—	—	—
69P/Taylor	SP Comet	1	14.947 ± 0.009	—	—	—	—	—	—	—
70P/Kojima	SP Comet	2	15.912 ± 0.009	22.758 ± 0.000	—	0.600 ± 0.090	—	—	—	—
71P/Clark	SP Comet	2	18.097 ± 0.009	27.065 ± 0.000	—	0.640 ± 0.070	—	—	—	—
72P/DF	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
73P/SW3	SP Comet	1	16.850 ± 0.050	10.751 ± 0.000	—	0.480 ± 0.235	—	—	—	—
73P/SW3C	SP Comet	1	18.097 ± 0.009	—	—	—	—	—	—	—
74P/SC	SP Comet	1	15.518 ± 0.009	—	—	—	—	—	—	—
75P/Kohoutek	SP Comet	1	15.754 ± 0.009	—	—	—	—	—	—	—
76P/WKI	SP Comet	1	19.667 ± 0.009	—	—	—	—	—	—	—
77P/Longmore	SP Comet	1	15.358 ± 0.009	—	—	—	—	—	—	—
78P/Gehrels2	SP Comet	1	16.498 ± 0.009	—	—	—	—	—	—	—
79P/dTH	SP Comet	1	16.529 ± 0.009	—	—	—	—	—	—	—
81P/Wild2	SP Comet	1	15.754 ± 0.009	—	—	—	—	—	—	—
82P/Gehrels3	SP Comet	1	17.943 ± 0.009	—	—	—	—	—	—	—
84P/Giclas	SP Comet	2	17.488 ± 0.009	-3.328 ± 0.000	—	0.320 ± 0.030	—	—	—	—
86P/Wild3	SP Comet	3	19.092 ± 0.009	18.211 ±35.399	1.580 ± 0.080	0.555 ± 0.385	—	—	—	—
87P/Bus	SP Comet	2	20.024 ± 0.009	16.889 ± 0.000	—	0.543 ± 0.020	—	—	—	—
88P/Howell	SP Comet	1	15.866 ± 0.009	—	—	—	—	—	—	—

Table A.1. continued.

Object	Class(1)	Epochs(2)	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
89P/Russell2	SP Comet	1	16.864 ± 0.009	—	—	—	—	—	—	—
90P/Gehrels1	SP Comet	1	14.602 ± 0.009	—	—	—	—	—	—	—
91P/Russell3	SP Comet	1	16.690 ± 0.009	—	—	—	—	—	—	—
92P/Sanguin	SP Comet	2	16.882 ± 0.009	16.937 ± 1.982	—	0.540 ± 0.040	0.540 ± 0.040	—	—	—
93P/HL	SP Comet	1	—	-7.552 ± 0.000	—	0.267 ± 0.075	—	—	—	—
94P/Russell4	SP Comet	1	15.866 ± 0.009	—	—	—	—	—	—	—
96P/Machholz1	SP Comet	2	14.734 ± 0.009	6.036 ± 0.000	—	0.429 ± 0.027	—	—	—	—
97P/MB	SP Comet	1	16.107 ± 0.009	—	—	—	—	—	—	—
98P/Takamizawa	SP Comet	1	14.418 ± 0.009	—	—	—	—	—	—	—
99P/Kowal1	SP Comet	1	13.853 ± 0.009	—	—	—	—	—	—	—
100P/Hartley1	SP Comet	1	16.690 ± 0.009	—	—	—	—	—	—	—
101P/Chernykh	SP Comet	1	15.358 ± 0.009	—	—	—	—	—	—	—
103P/Hartley2	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
104P/Kowal2	SP Comet	1	17.259 ± 0.009	—	—	—	—	—	—	—
105P/SB	SP Comet	1	17.259 ± 0.009	—	—	—	—	—	—	—
106P/Schuster	SP Comet	2	17.394 ± 0.009	12.396 ± 2.913	1.010 ± 0.060	0.520 ± 0.060	0.450 ± 0.060	—	—	—
107P/WH	SP Comet	6	15.865 ± 0.220	0.119 ± 4.538	0.674 ± 0.089	0.361 ± 0.048	—	—	—	—
109P/ST	SP Comet	2	12.002 ± 0.376	18.608 ± 0.000	—	0.560 ± 0.050	—	—	—	—
110P/Hartley3	SP Comet	2	15.597 ± 0.009	30.401 ± 0.000	—	0.670 ± 0.090	—	—	—	—
111P/HRC	SP Comet	1	18.369 ± 0.009	—	—	—	—	—	—	—
112P/UN	SP Comet	2	17.488 ± 0.009	15.593 ± 0.000	—	0.530 ± 0.040	—	—	—	—
113P/Spitaler	SP Comet	1	17.053 ± 0.009	—	—	—	—	—	—	—
114P/WS	SP Comet	2	17.799 ± 0.009	12.158 ± 1.087	0.850 ± 0.030	0.460 ± 0.020	0.540 ± 0.020	—	—	—
115P/Maury	SP Comet	1	17.033 ± 0.009	—	—	—	—	—	—	—
116P/Wild4	SP Comet	1	14.539 ± 0.009	—	—	—	—	—	—	—
117P/HRA	SP Comet	1	14.304 ± 0.009	—	—	—	—	—	—	—
118P/SL	SP Comet	1	15.358 ± 0.009	—	—	—	—	—	—	—
119P/PH	SP Comet	1	15.270 ± 0.009	—	—	—	—	—	—	—
120P/Mueller1	SP Comet	1	16.379 ± 0.009	—	—	—	—	—	—	—
121P/SH	SP Comet	1	16.212 ± 0.009	—	—	—	—	—	—	—
123P/WH	SP Comet	1	15.547 ± 0.009	—	—	—	—	—	—	—
124P/Mrkos	SP Comet	1	16.239 ± 0.009	—	—	—	—	—	—	—
125P/Spacewatch	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
126P/IRAS	SP Comet	1	16.280 ± 0.009	—	—	—	—	—	—	—
128P/SH	SP Comet	1	15.451 ± 0.009	—	—	—	—	—	—	—
129P/SL	SP Comet	1	15.358 ± 0.009	—	—	—	—	—	—	—

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
130P/McNH	SP Comet	1	15.983 ± 0.009	—	—	—	—	—	—	—
131P/Mueller2	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
132P/HRA	SP Comet	1	17.488 ± 0.009	—	—	—	—	—	—	—
134P/KV	SP Comet	1	16.529 ± 0.009	—	—	—	—	—	—	—
135P/SL	SP Comet	1	16.239 ± 0.009	—	—	—	—	—	—	—
136P/Mueller3	SP Comet	1	15.866 ± 0.009	—	—	—	—	—	—	—
137P/SL	SP Comet	1	14.947 ± 0.009	—	—	—	—	—	—	—
138P/SL	SP Comet	1	17.744 ± 0.009	—	—	—	—	—	—	—
139P/VO	SP Comet	1	15.185 ± 0.009	—	—	—	—	—	—	—
140P/BS	SP Comet	1	15.451 ± 0.009	—	—	—	—	—	—	—
141P/Machholz2	SP Comet	1	17.259 ± 0.009	—	—	—	—	—	—	—
143P/KM	SP Comet	5	13.598 ± 0.009	20.354 ± 1.102	0.820 ± 0.023	0.580 ± 0.020	0.560 ± 0.021	—	—	—
144P/Kushida	SP Comet	1	16.864 ± 0.009	—	—	—	—	—	—	—
147P/KM	SP Comet	1	20.648 ± 0.009	—	—	—	—	—	—	—
148P/AL	SP Comet	1	15.648 ± 0.009	—	—	—	—	—	—	—
152P/HL	SP Comet	1	13.946 ± 0.009	—	—	—	—	—	—	—
154P/Brewington	SP Comet	1	16.379 ± 0.009	—	—	—	—	—	—	—
166P/2001T4	Centaurs	2	—	36.293 ± 1.976	0.870 ± 0.040	0.695 ± 0.030	0.735 ± 0.060	—	—	—
204P/Wild2	SP Comet	1	—	—	—	—	0.436 ± 0.093	—	—	—
1172-Aneas	J.Trojan	2	8.729 ± 0.042	9.261 ± 0.863	0.727 ± 0.030	0.510 ± 0.022	0.400 ± 0.030	1.577 ± 0.036	0.430 ± 0.042	0.135 ± 0.036
1173-Anchises	J.Trojan	1	8.793 ± 0.059	4.286 ± 1.443	0.811 ± 0.034	0.402 ± 0.035	0.403 ± 0.052	—	—	—
1647-Menelaus	J.Trojan	1	—	6.803 ± 1.630	—	0.428 ± 0.043	0.438 ± 0.061	—	—	—
1871-Astyanax	J.Trojan	3	11.149 ± 0.093	7.777 ± 2.485	0.716 ± 0.071	0.456 ± 0.053	0.424 ± 0.089	1.422 ± 0.103	0.373 ± 0.053	0.123 ± 0.040
1993 RO	Res. 3:2	2	8.612 ± 0.134	24.485 ± 4.231	0.850 ± 0.070	0.590 ± 0.137	0.480 ± 0.113	—	—	—
1994 ES$_2$	Classic Cold	1	7.509 ± 0.130	—	—	—	—	—	—	—
1994 EV$_3$	Classic Cold	4	7.048 ± 0.178	30.400 ± 7.250	1.065 ± 0.110	0.588 ± 0.156	0.800 ± 0.126	—	—	—
1994 TA	Centaurs	2	11.421 ± 0.126	31.545 ± 6.243	1.261 ± 0.139	0.672 ± 0.080	0.740 ± 0.210	—	—	—
1995 DB$_2$	Classic Cold	2	8.058 ± 0.120	54.335 ± 0.000	—	—	—	—	—	—
1995 DC$_2$	Classic Cold	5	6.809 ± 0.204	35.475 ± 7.654	—	0.770 ± 0.160	0.580 ± 0.160	—	—	—
1995 FB$_{21}$	Classic Cold	4	7.017 ± 0.099	—	—	—	—	—	—	—
1995 HM$_5$	Res. 3:2	8	7.849 ± 0.109	9.432 ± 3.661	0.649 ± 0.102	0.460 ± 0.097	0.428 ± 0.126	—	1.180 ± 0.470	—
1995 WY$_2$	Classic Cold	2	6.935 ± 0.149	19.923 ±11.862	1.030 ± 0.280	0.600 ± 0.230	0.510 ± 0.280	—	—	—
1996 KV$_1$	Classic Hot	1	—	—	—	—	—	—	0.430 ± 0.256	—
1996 RQ$_{20}$	Classic Hot	7	6.872 ± 0.100	22.364 ± 4.307	0.935 ± 0.141	0.558 ± 0.096	0.591 ± 0.109	—	0.380 ± 0.226	—
1996 RR$_{20}$	Res. 3:2	4	6.811 ± 0.252	36.280 ± 5.193	1.143 ± 0.106	0.730 ± 0.095	0.628 ± 0.125	—	—	—
1996 TC$_{68}$	Classic Hot	1	6.734 ± 0.073	22.758 ± 0.000	—	0.600 ± 0.078	—	—	—	—

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
1996 TK$_{66}$	Classic Cold	4	6.190 ± 0.116	29.906 ± 4.054	0.993 ± 0.062	0.680 ± 0.067	0.551 ± 0.097	—	—	—
1996 TS$_{66}$	Classic Hot	7	5.947 ± 0.130	26.561 ± 4.871	1.028 ± 0.079	0.672 ± 0.106	0.637 ± 0.088	1.824 ± 0.178	0.650 ± 0.071	—
1997 CT$_{29}$	Classic Cold	4	6.452 ± 0.173	32.698 ± 4.508	—	0.762 ± 0.105	0.490 ± 0.120	—	0.410 ± 0.238	—
1997 CV$_{29}$	Classic Hot	2	7.154 ± 0.030	28.171 ± 2.056	1.210 ± 0.010	0.650 ± 0.020	—	—	0.360 ± 0.243	—
1997 GA$_{45}$	Classic Hot	1	7.744 ± 0.500	—	—	—	—	—	—	—
1997 QH$_{4}$	Classic Hot	4	7.128 ± 0.175	27.144 ± 4.569	1.088 ± 0.143	0.641 ± 0.092	0.631 ± 0.107	—	—	—
1997 RL$_{13}$	Classic Hot	1	9.361 ± 0.300	—	—	—	—	—	—	—
1997 RT$_{5}$	Classic Hot	4	6.951 ± 0.379	15.015 ± 4.506	1.075 ± 0.121	0.474 ± 0.107	0.539 ± 0.091	—	0.380 ± 0.231	—
1997 RX$_{9}$	Classic Hot	1	7.802 ± 0.100	—	—	—	—	—	—	—
1997 SZ$_{10}$	Res.(other)	1	8.148 ± 0.060	28.167 ± 2.909	1.140 ± 0.080	0.650 ± 0.030	—	—	—	—
1998 FS$_{144}$	Classic Hot	4	6.717 ± 0.105	23.851 ± 3.089	0.950 ± 0.044	0.588 ± 0.060	0.510 ± 0.085	—	0.390 ± 0.228	—
1998 KG$_{62}$	Classic Cold	5	6.367 ± 0.283	24.857 ± 3.762	1.039 ± 0.105	0.609 ± 0.095	0.610 ± 0.078	—	0.410 ± 0.231	—
1998 KS$_{65}$	Classic Cold	2	7.166 ± 0.040	26.149 ± 1.858	1.090 ± 0.040	0.640 ± 0.020	—	—	—	—
1998 KY$_{61}$	Classic Cold	1	—	—	—	—	—	—	0.350 ± 0.278	—
1998 UR$_{43}$	Res. 3:2	4	8.124 ± 0.134	14.454 ± 7.356	0.784 ± 0.101	0.583 ± 0.120	0.354 ± 0.175	—	—	—
1998 UU$_{43}$	Res.(other)	2	6.925 ± 0.110	14.799 ± 3.950	—	0.610 ± 0.120	0.400 ± 0.114	—	0.490 ± 0.273	—
1998 WS$_{31}$	Res. 3:2	2	7.931 ± 0.203	18.738 ± 6.008	0.726 ± 0.080	0.606 ± 0.102	0.439 ± 0.172	—	—	—
1998 WU$_{24}$	Scattered	1	—	12.934 ± 1.361	0.780 ± 0.034	0.530 ± 0.037	0.460 ± 0.051	1.670 ± 0.043	0.430 ± 0.125	0.240 ± 0.189
1998 WV$_{24}$	Classic Cold	2	7.126 ± 0.067	11.777 ± 3.357	0.770 ± 0.010	0.502 ± 0.058	0.450 ± 0.106	—	—	—
1998 WV$_{31}$	Res. 3:2	2	7.639 ± 0.072	13.835 ± 4.507	0.790 ± 0.099	0.521 ± 0.075	0.481 ± 0.144	—	—	—
1998 WW$_{31}$	Classic Hot	1	—	8.864 ± 0.000	—	—	—	—	—	—
1998 WW$_{31+B}$	Classic Hot	1	—	2.628 ± 0.000	—	—	—	—	—	—
1998 WX$_{24}$	Classic Cold	2	6.241 ± 0.099	30.875 ± 3.793	1.090 ± 0.050	0.727 ± 0.086	0.500 ± 0.092	—	—	—
1998 WX$_{31}$	Classic Cold	3	6.159 ± 0.095	29.252 ± 3.312	—	0.638 ± 0.083	0.653 ± 0.081	—	0.400 ± 0.235	—
1998 WY$_{24}$	Classic Cold	2	6.441 ± 0.086	29.095 ± 3.185	—	0.620 ± 0.092	0.680 ± 0.078	—	0.400 ± 0.240	—
1998 WZ$_{31}$	Res. 3:2	3	8.045 ± 0.115	6.687 ± 4.513	0.727 ± 0.093	0.489 ± 0.114	0.339 ± 0.114	—	0.400 ± 0.234	—
1998 XY$_{95}$	Detached	2	6.438 ± 0.143	41.429 ± 5.409	0.930 ± 0.233	0.720 ± 0.145	0.752 ± 0.126	—	—	—
1999 CB$_{119}$	Classic Hot	1	6.737 ± 0.076	33.869 ± 2.678	1.212 ± 0.102	0.714 ± 0.076	0.645 ± 0.062	—	—	—
1999 CD$_{158}$	Res.(other)	5	4.822 ± 0.099	16.860 ± 2.607	0.864 ± 0.056	0.520 ± 0.053	0.575 ± 0.064	1.862 ± 0.076	0.423 ± 0.135	0.048 ± 0.116
1999 CF$_{119}$	Detached	3	6.933 ± 0.133	14.704 ± 4.163	—	0.622 ± 0.115	0.365 ± 0.106	—	0.380 ± 0.226	—
1999 CH$_{119}$	Classic Hot	1	—	—	—	—	—	—	0.320 ± 0.266	—
1999 CJ$_{119}$	Classic Cold	1	—	—	—	—	—	—	0.450 ± 0.265	—
1999 CL$_{119}$	Classic Hot	2	5.699 ± 0.072	19.530 ± 3.359	—	0.497 ± 0.077	0.665 ± 0.094	—	0.450 ± 0.282	—
1999 CQ$_{133}$	Classic Hot	1	—	—	—	—	—	—	0.460 ± 0.282	—
1999 CX$_{131}$	Res.(other)	3	6.910 ± 0.107	19.521 ± 4.293	0.918 ± 0.124	0.664 ± 0.128	0.434 ± 0.105	—	0.370 ± 0.238	—
1999 HJ$_{12}$	Classic Cold	2	—	30.391 ± 0.000	—	—	—	—	0.480 ± 0.598	—

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
1999 HS$_{11}$	Classic Cold	3	6.331 ± 0.079	31.102 ± 3.766	1.121 ± 0.082	0.698 ± 0.056	0.600 ± 0.090	—	—	—
1999 HV$_{11}$	Classic Cold	1	7.003 ± 0.050	21.706 ± 2.057	1.110 ± 0.060	0.590 ± 0.020	—	—	—	—
1999 OD$_{4}$	Classic Hot	1	—	—	—	—	—	—	0.460 ± 0.282	—
1999 OE$_{4}$	Classic Cold	4	6.831 ± 0.177	13.989 ± 7.765	1.103 ± 0.236	0.567 ± 0.159	0.414 ± 0.180	—	0.360 ± 0.216	—
1999 OH$_{4}$	Classic Hot	2	6.321 ± 0.123	-7.656 ± 9.026	—	0.200 ± 0.134	0.430 ± 0.335	—	0.330 ± 0.328	—
1999 OJ$_{4}$	Classic Cold	5	6.912 ± 0.062	26.192 ± 3.113	1.098 ± 0.157	0.668 ± 0.072	0.549 ± 0.073	—	0.230 ± 0.197	—
1999 OJ$_{4+B}$	Classic Cold	1	—	34.360 ± 0.000	—	—	—	—	—	—
1999 OM$_{4}$	Classic Cold	1	7.502 ± 0.100	18.976 ± 3.909	1.137 ± 0.135	0.602 ± 0.104	0.499 ± 0.088	—	—	—
1999 RC$_{215}$	Classic Cold	2	6.571 ± 0.126	33.893 ± 4.703	—	0.810 ± 0.134	0.520 ± 0.120	—	0.320 ± 0.225	—
1999 RT$_{214}$	Classic Cold	1	—	35.732 ± 0.000	—	—	—	—	—	—
1999 RX$_{214}$	Classic Cold	3	6.413 ± 0.052	20.207 ± 2.817	1.054 ± 0.072	0.593 ± 0.065	0.530 ± 0.066	—	—	—
1999 RY$_{214}$	Classic Hot	2	7.010 ± 0.065	18.063 ± 3.131	0.693 ± 0.087	0.565 ± 0.080	0.530 ± 0.084	—	—	—
1999 TR$_{11}$	Res. 3:2	2	8.144 ± 0.152	37.094 ± 4.048	1.020 ± 0.080	0.750 ± 0.097	0.650 ± 0.122	—	—	—
1999 XY$_{143}$	Classic Hot	1	5.924 ± 0.065	26.014 ± 2.399	—	0.590 ± 0.071	0.660 ± 0.064	—	—	—
2000 AF$_{255}$	Detached	1	—	—	—	—	—	—	0.460 ± 0.265	—
2000 CE$_{105}$	Classic Cold	2	—	14.512 ± 0.000	—	—	—	—	0.160 ± 0.184	—
2000 CF$_{105}$	Classic Cold	6	—	24.245 ± 0.000	—	—	—	—	0.400 ± 0.266	—
2000 CF$_{105+B}$	Classic Cold	1	—	21.377 ± 0.000	—	—	—	—	—	—
2000 CG$_{105}$	Classic Hot	3	6.124 ± 0.311	—	—	0.107 ± 0.246	0.293 ± 0.265	—	0.510 ± 0.298	—
2000 CK$_{105}$	Res. 3:2	2	6.370 ± 0.118	25.479 ± 4.225	—	0.590 ± 0.127	0.650 ± 0.114	—	0.390 ± 0.256	—
2000 CL$_{104}$	Classic Cold	4	6.642 ± 0.229	23.634 ± 4.673	1.223 ± 0.167	0.600 ± 0.119	0.612 ± 0.128	—	0.450 ± 0.285	—
2000 CN$_{105}$	Classic Cold	4	5.261 ± 0.072	29.677 ± 1.174	1.100 ± 0.020	0.636 ± 0.072	0.640 ± 0.020	—	—	—
2000 CO$_{105}$	Classic Hot	2	5.594 ± 0.078	22.327 ± 2.904	—	0.620 ± 0.085	0.550 ± 0.078	—	0.380 ± 0.228	—
2000 CP$_{104}$	Classic Hot	2	—	18.106 ± 0.000	—	—	—	—	0.440 ± 0.289	—
2000 CQ$_{105}$	Detached	5	5.965 ± 0.049	7.864 ± 2.902	0.671 ± 0.023	0.449 ± 0.038	0.346 ± 0.101	—	0.420 ± 0.262	—
2000 CQ$_{114}$	Classic Cold	3	6.660 ± 0.147	34.780 ± 4.289	—	0.690 ± 0.156	0.650 ± 0.134	—	0.420 ± 0.403	—
2000 CQ$_{114+B}$	Classic Cold	1	—	33.683 ± 0.000	—	—	—	—	—	—
2000 FS$_{53}$	Classic Cold	2	7.300 ± 0.080	34.603 ± 1.976	1.060 ± 0.040	0.710 ± 0.020	—	—	—	—
2000 FV$_{53}$	Res. 3:2	1	7.550 ± 0.087	17.018 ± 4.070	—	0.448 ± 0.094	0.679 ± 0.116	—	—	—
2000 FZ$_{53}$	Centaurs	2	10.990 ± 0.085	14.413 ± 3.939	—	0.686 ± 0.090	0.238 ± 0.103	—	—	—
2000 GV$_{146}$	Classic Cold	1	—	35.732 ± 0.000	—	—	—	—	—	—
2000 KK$_{4}$	Classic Hot	3	5.982 ± 0.103	17.292 ± 2.477	0.910 ± 0.040	0.580 ± 0.102	0.640 ± 0.064	1.790 ± 0.106	—	—
2000 KL$_{4}$	Classic Hot	1	—	27.864 ± 0.000	—	—	—	—	—	—
2000 OU$_{69}$	Classic Cold	3	6.839 ± 0.120	10.128 ± 0.000	—	0.473 ± 0.130	—	—	0.400 ± 0.235	—
2000 PD$_{30}$	Classic Cold	2	—	19.719 ± 0.000	—	—	—	—	0.560 ± 0.336	—
2000 PE$_{30}$	Detached	7	5.796 ± 0.081	2.353 ± 3.158	0.752 ± 0.069	0.373 ± 0.077	0.410 ± 0.049	1.646 ± 0.080	0.452 ± 0.114	0.260 ± 0.072

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
2000 PH_{30}	Detached	1	—	—	—	—	—	—	0.550 ± 0.361	—
2000 QL_{251}	Classic Cold	1	—	6.266 ± 0.000	—	—	—	—	—	—
2000 QL_{251+B}	Classic Cold	1	—	12.082 ± 0.000	—	—	—	—	—	—
2001 FL_{185}	Classic Cold	1	—	23.082 ± 0.000	—	—	—	—	—	—
2001 FM_{194}	Detached	1	7.582 ± 0.040	7.035 ± 2.909	0.760 ± 0.030	0.440 ± 0.030	—	—	—	—
2001 FU_{172}	Res. 3:2	1	8.165 ± 0.181	22.552 ± 8.420	—	0.670 ± 0.192	0.470 ± 0.225	—	—	—
2001 KA_{77}	Classic Hot	4	5.050 ± 0.094	37.759 ± 3.264	1.104 ± 0.107	0.704 ± 0.064	0.716 ± 0.120	—	—	—
2001 KB_{77}	Res. 3:2	6	7.373 ± 0.063	11.050 ± 3.211	—	0.434 ± 0.083	0.548 ± 0.089	—	—	—
2001 KD_{77}	Res. 3:2	9	5.926 ± 0.104	24.005 ± 2.575	1.123 ± 0.054	0.624 ± 0.070	0.565 ± 0.069	2.294 ± 0.092	0.366 ± 0.141	—
2001 KG_{77}	Scattered	1	8.340 ± 0.120	7.034 ± 5.595	0.810 ± 0.040	0.440 ± 0.060	—	—	—	—
2001 KY_{76}	Res. 3:2	1	—	—	—	—	—	—	0.390 ± 0.228	—
2001 OG_{109}	Classic Cold	1	—	—	—	—	—	—	0.350 ± 0.300	—
2001 OK_{108}	Classic Cold	1	—	—	—	—	—	—	0.430 ± 0.275	—
2001 QC_{298}	Classic Hot	3	6.421 ± 0.030	10.333 ± 2.434	0.750 ± 0.080	0.490 ± 0.030	0.480 ± 0.040	—	0.430 ± 0.323	—
2001 QC_{298+B}	Classic Hot	1	—	6.266 ± 0.000	—	—	—	—	—	—
2001 QD_{298}	Classic Hot	1	6.185 ± 0.170	30.399 ± 8.330	0.970 ± 0.130	0.670 ± 0.090	—	—	—	—
2001 QF_{298}	Res. 3:2	8	5.128 ± 0.126	2.287 ± 2.687	0.644 ± 0.070	0.381 ± 0.062	0.360 ± 0.085	1.126 ± 0.124	0.317 ± 0.172	0.165 ± 0.113
2001 QX_{322}	Detached	3	6.388 ± 0.080	18.862 ± 5.260	0.914 ± 0.058	0.563 ± 0.056	—	—	0.410 ± 0.247	—
2001 XR_{254}	Classic Cold	1	—	15.011 ± 0.000	—	—	—	—	—	—
2001 XR_{254+B}	Classic Cold	1	—	16.024 ± 0.000	—	—	—	—	—	—
2001 XU_{254}	Classic Hot	1	—	—	—	—	—	—	0.370 ± 0.226	—
2001 XZ_{255}	Centaurs	1	10.800 ± 0.080	39.753 ± 6.501	1.170 ± 0.020	0.750 ± 0.070	—	—	—	—
2002 CB_{249}	Centaurs	1	10.587 ± 0.109	5.278 ± 4.487	—	0.492 ± 0.116	0.300 ± 0.114	—	—	—
2002 DH_{5}	Centaurs	1	10.190 ± 0.061	4.151 ± 2.833	0.663 ± 0.072	0.391 ± 0.069	0.416 ± 0.081	—	—	—
2002 GB_{32}	Scattered	1	7.637 ± 0.010	18.001 ± 1.087	0.880 ± 0.028	0.510 ± 0.020	0.610 ± 0.020	—	—	—
2002 PP_{149}	Classic Hot	1	7.256 ± 0.030	-6.534 ± 3.793	0.850 ± 0.100	0.280 ± 0.040	—	—	—	—
2003 FZ_{129}	Detached	1	6.982 ± 0.020	10.329 ± 1.812	0.840 ± 0.057	0.480 ± 0.040	0.460 ± 0.030	—	—	—
2003 GH_{55}	Classic Cold	1	5.949 ± 0.050	25.973 ± 5.595	1.120 ± 0.050	0.630 ± 0.060	—	—	—	—
2003 HB_{57}	Scattered	1	7.389 ± 0.020	13.225 ± 1.525	0.830 ± 0.042	0.480 ± 0.030	0.540 ± 0.030	—	—	—
2003 HX_{56}	Classic Hot	1	7.030 ± 0.209	-1.963 ±13.676	—	0.350 ± 0.226	0.260 ± 0.459	—	—	—
2003 QA_{92}	Classic Cold	1	—	25.973 ± 3.793	1.040 ± 0.030	0.630 ± 0.040	—	—	—	—
2003 QD_{112}	Centaurs	1	11.641 ± 0.030	—	—	—	—	—	—	—
2003 QK_{91}	Detached	1	6.967 ± 0.030	11.829 ± 1.812	0.870 ± 0.057	0.500 ± 0.040	0.470 ± 0.030	—	—	—
2003 QQ_{91}	Classic Hot	1	—	13.624 ± 7.416	0.670 ± 0.060	0.510 ± 0.080	—	—	—	—
2003 QW_{111}	Res.(other)	1	—	27.864 ± 0.000	—	—	—	—	—	—
2003 QW_{111+B}	Res.(other)	1	—	30.391 ± 0.000	—	—	—	—	—	—

Table A.1. continued.

Object	Class[1]	Epochs[2]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
2003 QW$_{90}$	Res. 3:2	2	—	15.349 ± 0.000	—	—	—	1.930 ± 0.162	—	—
2003 QY$_{90}$	Classic Cold	1	—	32.348 ± 0.000	—	—	—	—	—	—
2003 QY$_{90+B}$	Classic Cold	1	—	32.348 ± 0.000	—	—	—	—	—	—
2003 SQ$_{317}$	Classic Hot	1	6.161 ± 0.020	—	—	—	—	—	-0.450 ± 0.197	—
2003 TH$_{58}$	Res. 3:2	1	7.007 ± 0.045	5.615 ± 2.028	0.610 ± 0.064	0.380 ± 0.045	0.480 ± 0.045	1.160 ± 0.098	1.280 ± 0.201	—
2003 TJ$_{58}$	Classic Cold	1	—	19.719 ± 0.000	—	—	—	—	—	—
2003 TJ$_{58+B}$	Classic Cold	1	—	18.639 ± 0.000	—	—	—	—	—	—
2003 UY$_{291}$	Classic Cold	1	—	20.163 ± 3.383	0.880 ± 0.099	0.510 ± 0.070	0.670 ± 0.070	—	—	—
2003 UZ$_{117}$	Classic Hot	4	4.961 ± 0.020	-0.537 ± 1.824	0.676 ± 0.031	0.350 ± 0.028	0.334 ± 0.039	—	—	—
2003 YL$_{179}$	Classic Cold	1	—	7.953 ± 9.243	0.810 ± 0.040	0.450 ± 0.100	—	—	—	—
2004 OJ$_{14}$	Detached	1	6.991 ± 0.020	15.681 ± 1.525	0.900 ± 0.042	0.520 ± 0.030	0.540 ± 0.030	—	—	—
2004 PB$_{108}$	Classic Hot	1	—	19.177 ± 0.000	—	—	—	—	—	—
2004 PB$_{108+B}$	Classic Hot	1	—	21.377 ± 0.000	—	—	—	—	—	—
2004 PT$_{107}$	Classic Hot	1	5.847 ± 0.010	—	—	—	—	—	0.540 ± 0.228	—
2004 PY$_{42}$	1	—	17.581 ± 1.360	0.770 ± 0.030	0.550 ± 0.030	0.540 ± 0.020	—	—	—	
2004 VN$_{112}$	Detached	1	—	12.396 ± 2.913	0.900 ± 0.085	0.520 ± 0.060	0.450 ± 0.060	—	—	—
2004 XR$_{190}$	Detached	1	3.937 ± 0.030	10.679 ± 1.982	0.790 ± 0.057	0.450 ± 0.040	0.520 ± 0.040	—	—	—
2005 CB$_{79}$	Classic Hot	1	4.375 ± 0.028	1.054 ± 1.574	0.740 ± 0.036	0.350 ± 0.036	0.380 ± 0.036	1.040 ± 0.076	-0.510 ± 0.175	—
2005 EO$_{297}$	Detached	1	7.220 ± 0.030	13.673 ± 2.955	0.840 ± 0.071	0.480 ± 0.050	0.570 ± 0.080	—	—	—
2005 EO$_{304}$	Classic Cold	1	—	38.554 ± 0.000	—	—	—	—	—	—
2005 EO$_{304+B}$	Classic Cold	1	—	33.683 ± 0.000	—	—	—	—	—	—
2005 GE$_{187}$	Res. 3:2	1	7.214 ± 0.030	—	—	—	—	—	0.660 ± 0.144	—
2005 PU$_{21}$	Scattered	1	6.091 ± 0.020	30.943 ± 1.087	1.140 ± 0.028	0.650 ± 0.020	0.680 ± 0.020	—	—	—
2005 SD$_{278}$	Detached	1	5.916 ± 0.020	17.797 ± 1.087	0.970 ± 0.028	0.560 ± 0.020	0.530 ± 0.020	—	—	—
2006 SQ$_{372}$	Scattered	1	7.667 ± 0.020	24.677 ± 1.702	1.030 ± 0.042	0.590 ± 0.030	0.650 ± 0.040	—	—	—
2007 TG$_{422}$	Scattered	1	6.186 ± 0.010	13.918 ± 1.982	0.880 ± 0.057	0.510 ± 0.040	0.510 ± 0.040	—	—	—
2007 VJ$_{305}$	Detached	1	6.713 ± 0.020	14.913 ± 1.525	0.920 ± 0.042	0.520 ± 0.030	0.520 ± 0.030	—	—	—
2008 KV$_{42}$	Scattered	1	8.565 ± 0.040	8.461 ± 2.913	0.820 ± 0.085	0.470 ± 0.060	0.420 ± 0.060	—	—	—
2008 OG$_{19}$	Detached	1	4.611 ± 0.010	18.921 ± 0.677	0.940 ± 0.014	0.530 ± 0.010	0.590 ± 0.010	—	—	—
2008 YB$_{3}$	SP Comet	1	9.715 ± 0.010	10.549 ± 0.677	0.800 ± 0.014	0.460 ± 0.010	0.490 ± 0.010	—	—	—
2060-Chiron	Centaurs	34	6.092 ± 0.069	0.114 ± 0.996	0.700 ± 0.020	0.361 ± 0.017	0.325 ± 0.023	1.199 ± 0.110	0.294 ± 0.079	0.065 ± 0.094
2223-Sarpedon	J.Trojan	1	9.265 ± 0.046	8.785 ± 1.244	0.753 ± 0.032	0.465 ± 0.025	0.440 ± 0.041	—	—	—
2357-Phereclos	J.Trojan	1	8.817 ± 0.078	7.601 ± 1.876	0.718 ± 0.059	0.427 ± 0.045	0.463 ± 0.068	—	—	—
3548-Eurybates	J.Trojan	1	—	-0.087 ± 1.847	0.677 ± 0.052	0.352 ± 0.045	0.339 ± 0.067	—	—	—
4035-1986 WD	J.Trojan	2	9.489 ± 0.080	10.259 ± 1.995	0.752 ± 0.040	0.484 ± 0.043	0.451 ± 0.069	—	—	—
4829-Sergestus	J.Trojan	1	11.122 ± 0.068	4.196 ± 1.856	0.851 ± 0.050	0.420 ± 0.039	0.372 ± 0.065	—	—	—

Table A.1. continued.

Object	Class[1]	Epochs[2]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
5130-Ilioneus	J.Trojan	1	9.656 ± 0.048	9.188 ± 1.378	0.763 ± 0.034	0.481 ± 0.026	0.424 ± 0.046	—	—	—
5145-Pholus	Centaurs	41	7.165 ± 0.076	48.354 ± 1.930	1.261 ± 0.121	0.788 ± 0.036	0.822 ± 0.054	2.612 ± 0.048	0.391 ± 0.047	-0.037 ± 0.047
5244-Amphilochos	J.Trojan	1	—	3.187 ± 1.754	—	0.407 ± 0.044	0.363 ± 0.064	—	—	—
5258-1989 AU_1	J.Trojan	1	—	8.233 ± 1.590	—	0.466 ± 0.041	0.425 ± 0.059	—	—	—
5511-Cloanthus	J.Trojan	1	10.287 ± 0.047	10.774 ± 1.229	0.906 ± 0.027	0.442 ± 0.027	0.526 ± 0.042	—	—	—
6545-1986 TR_6	J.Trojan	1	10.219 ± 0.073	10.572 ± 1.962	0.734 ± 0.041	0.499 ± 0.042	0.436 ± 0.069	—	—	—
6998-Tithonus	J.Trojan	1	11.284 ± 0.059	8.155 ± 1.282	0.787 ± 0.040	0.455 ± 0.032	0.438 ± 0.046	—	—	—
7066-Nessus	Centaurs	17	9.054 ± 0.075	39.777 ± 3.448	1.090 ± 0.040	0.763 ± 0.059	0.689 ± 0.087	2.290 ± 0.040	0.309 ± 0.268	-0.089 ± 0.385
7352-1994 CO	J.Trojan	1	9.873 ± 0.056	4.815 ± 1.629	0.713 ± 0.036	0.417 ± 0.034	0.397 ± 0.056	—	—	—
8405-Asbolus	Centaurs	43	8.999 ± 0.059	12.765 ± 1.370	0.738 ± 0.038	0.508 ± 0.053	0.505 ± 0.038	1.654 ± 0.048	0.386 ± 0.103	0.170 ± 0.171
9030-1989 UX_5	J.Trojan	1	11.121 ± 0.047	11.783 ± 1.115	0.887 ± 0.024	0.493 ± 0.027	0.480 ± 0.039	—	—	—
9430-Erichthonio	J.Trojan	1	11.306 ± 0.106	10.723 ± 3.060	0.742 ± 0.079	0.488 ± 0.060	0.456 ± 0.109	—	—	—
9818-Eurymachos	J.Trojan	1	—	-0.162 ± 1.824	0.673 ± 0.052	0.339 ± 0.046	0.355 ± 0.067	—	—	—
10199-Chariklo	Centaurs	64	6.508 ± 0.016	13.595 ± 0.883	0.802 ± 0.049	0.491 ± 0.016	0.520 ± 0.014	1.685 ± 0.110	0.414 ± 0.046	0.097 ± 0.048
10370-Hylonome	Centaurs	25	9.257 ± 0.159	9.668 ± 6.478	0.690 ± 0.110	0.469 ± 0.154	0.496 ± 0.189	1.310 ± 0.100	0.180 ± 0.085	0.270 ± 0.092
11089-1994 CS_8	J.Trojan	1	10.681 ± 0.098	4.732 ± 2.619	0.689 ± 0.073	0.423 ± 0.056	0.384 ± 0.094	—	—	—
11351-1997 TS_{25}	J.Trojan	1	10.793 ± 0.076	9.325 ± 2.033	0.739 ± 0.044	0.498 ± 0.044	0.402 ± 0.072	—	—	—
11488-1988 RM_{11}	J.Trojan	2	11.524 ± 0.194	6.507 ± 2.832	0.777 ± 0.110	0.436 ± 0.062	0.420 ± 0.103	—	—	—
11663-1997 GO_{24}	J.Trojan	1	10.838 ± 0.052	6.580 ± 1.438	0.837 ± 0.030	0.409 ± 0.030	0.463 ± 0.049	—	—	—
12917-1998 TG_{16}	J.Trojan	2	11.388 ± 0.073	11.839 ± 1.962	0.724 ± 0.042	0.537 ± 0.042	0.410 ± 0.069	1.707 ± 0.066	0.475 ± 0.086	0.205 ± 0.081
12921-1998 WZ_5	J.Trojan	2	10.948 ± 0.073	3.492 ± 1.876	0.673 ± 0.040	0.403 ± 0.047	0.380 ± 0.068	—	—	—
13463-Antiphos	J.Trojan	2	11.083 ± 0.066	7.093 ± 1.913	0.692 ± 0.045	0.449 ± 0.034	0.412 ± 0.066	1.417 ± 0.048	0.343 ± 0.055	0.103 ± 0.052
13862-1999 XT_{160}	J.Trojan	1	—	2.203 ± 1.754	—	0.381 ± 0.044	0.370 ± 0.064	—	—	—
14707-2000 CC_{20}	J.Trojan	2	11.410 ± 0.112	4.232 ± 1.902	0.752 ± 0.041	0.412 ± 0.035	0.385 ± 0.067	—	—	—
15094-1999 WB_2	J.Trojan	3	11.582 ± 0.118	5.186 ± 2.495	0.652 ± 0.065	0.477 ± 0.065	0.322 ± 0.094	1.401 ± 0.066	0.342 ± 0.062	0.095 ± 0.058
15502-1999 NV_{27}	J.Trojan	3	9.943 ± 0.075	7.368 ± 1.724	0.766 ± 0.047	0.445 ± 0.036	0.430 ± 0.060	1.565 ± 0.046	0.492 ± 0.041	0.152 ± 0.034
15535-2000 AT_{177}	J.Trojan	4	10.555 ± 0.075	9.836 ± 2.098	0.739 ± 0.043	0.470 ± 0.049	0.461 ± 0.082	1.681 ± 0.045	0.500 ± 0.048	0.123 ± 0.047
15760-1992 QB_1	Classic Cold	5	6.979 ± 0.094	27.538 ± 4.806	0.869 ± 0.143	0.707 ± 0.093	0.651 ± 0.166	—	—	—
15788-1993 SB	Res. 3:2	6	8.026 ± 0.143	12.407 ± 4.044	0.802 ± 0.071	0.475 ± 0.077	0.514 ± 0.114	—	0.450 ± 0.253	—
15789-1993 SC	Res. 3:2	17	6.740 ± 0.077	34.698 ± 4.012	1.045 ± 0.117	0.688 ± 0.074	0.697 ± 0.093	2.236 ± 0.200	0.412 ± 0.240	-0.040 ± 0.197
15807-1994 GV_9	Classic Cold	1	6.813 ± 0.091	38.552 ± 0.000	—	0.740 ± 0.099	—	—	—	—
15809-1994 JS	Res.(other)	2	7.479 ± 0.160	28.194 ± 6.000	—	0.760 ± 0.170	0.480 ± 0.149	—	0.460 ± 0.705	—
15810-1994 JR_1	Res. 3:2	9	6.873 ± 0.079	15.313 ± 4.751	1.010 ± 0.180	0.614 ± 0.114	0.538 ± 0.098	—	0.430 ± 0.242	—
15820-1994 TB	Res. 3:2	15	7.499 ± 0.116	37.669 ± 3.728	1.107 ± 0.126	0.697 ± 0.075	0.739 ± 0.099	2.368 ± 0.162	0.428 ± 0.119	0.120 ± 0.120
15836-1995 DA_2	Res.(other)	6	7.809 ± 0.091	16.356 ± 5.630	—	0.550 ± 0.110	0.500 ± 0.160	—	—	—
15874-1996 TL_{66}	Scattered	16	5.208 ± 0.131	1.451 ± 2.858	0.687 ± 0.072	0.369 ± 0.052	0.370 ± 0.077	1.452 ± 0.114	0.267 ± 0.144	-0.018 ± 0.138

Table A.1. continued.

Object	Class[1]	Epochs[2]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
15875-1996 TP$_{66}$	Res. 3:2	7	6.958 ± 0.076	30.636 ± 3.598	1.031 ± 0.112	0.655 ± 0.076	0.673 ± 0.086	2.309 ± 0.060	0.170 ± 0.078	0.020 ± 0.092
15883-1997 CR$_{29}$	Classic Hot	3	7.076 ± 0.135	20.484 ± 7.048	0.750 ± 0.152	0.538 ± 0.157	0.620 ± 0.182	—	0.490 ± 0.320	—
15977-1998 MA$_{11}$	J.Trojan	1	10.610 ± 0.046	8.770 ± 1.049	0.748 ± 0.033	0.465 ± 0.025	0.441 ± 0.036	—	—	—
16684-1994 JQ$_{1}$	Classic Cold	8	6.646 ± 0.113	31.346 ± 4.713	1.134 ± 0.068	0.736 ± 0.101	0.650 ± 0.123	—	—	—
17416-1988 RR$_{10}$	J.Trojan	1	12.739 ± 0.097	12.134 ± 2.732	0.742 ± 0.071	0.488 ± 0.055	0.498 ± 0.097	—	—	—
18060-1999 XJ$_{156}$	J.Trojan	1	—	3.456 ± 1.719	0.758 ± 0.056	0.412 ± 0.043	0.364 ± 0.063	—	—	—
18137-2000 OU$_{30}$	J.Trojan	1	11.131 ± 0.057	9.115 ± 1.218	0.733 ± 0.039	0.496 ± 0.031	0.409 ± 0.044	—	—	—
18268-Dardanos	J.Trojan	1	12.080 ± 0.070	12.538 ± 1.495	0.795 ± 0.042	0.529 ± 0.040	0.451 ± 0.056	—	—	—
18493-Demoleon	J.Trojan	2	10.813 ± 0.083	3.154 ± 2.460	0.703 ± 0.073	0.395 ± 0.047	0.380 ± 0.087	1.383 ± 0.045	0.384 ± 0.046	0.091 ± 0.040
18940-2000 QV$_{49}$	J.Trojan	1	11.615 ± 0.097	8.449 ± 2.608	0.709 ± 0.072	0.465 ± 0.055	0.429 ± 0.093	—	—	—
19255-1994 VK$_{8}$	Classic Cold	4	7.016 ± 0.163	24.540 ± 5.861	1.010 ± 0.060	0.659 ± 0.095	0.490 ± 0.255	—	0.520 ± 0.297	—
19299-1996 SZ$_{4}$	Res. 3:2	5	8.330 ± 0.166	13.725 ± 4.694	0.754 ± 0.100	0.522 ± 0.061	0.446 ± 0.154	—	—	—
19308-1996 TO$_{66}$	Classic Hot	16	4.520 ± 0.042	2.077 ± 2.168	0.671 ± 0.057	0.389 ± 0.043	0.356 ± 0.053	0.997 ± 0.101	—	—
19521-Chaos	Classic Hot	13	4.503 ± 0.090	23.292 ± 2.396	0.932 ± 0.054	0.608 ± 0.041	0.571 ± 0.087	1.835 ± 0.087	0.400 ± 0.095	0.033 ± 0.094
20000-Varuna	Classic Hot	8	3.455 ± 0.090	26.843 ± 1.917	0.906 ± 0.052	0.637 ± 0.040	0.628 ± 0.040	2.010 ± 0.050	0.564 ± 0.070	-0.038 ± 0.105
20108-1995 QZ$_{9}$	Res. 3:2	3	7.889 ± 0.399	14.511 ± 3.460	0.880 ± 0.040	0.515 ± 0.050	—	—	—	—
20161-1996 TR$_{66}$	Res.(other)	1	—	—	—	—	—	—	0.470 ± 0.296	—
20738-1999 XG$_{191}$	J.Trojan	2	11.536 ± 0.073	10.132 ± 1.962	0.776 ± 0.041	0.472 ± 0.042	0.467 ± 0.069	1.593 ± 0.062	0.520 ± 0.084	0.113 ± 0.081
23549-Epicles	J.Trojan	1	11.812 ± 0.118	7.916 ± 2.720	0.800 ± 0.071	0.485 ± 0.068	0.387 ± 0.101	—	—	—
23694-1997 KZ$_{3}$	J.Trojan	1	11.340 ± 0.053	8.337 ± 1.151	0.723 ± 0.035	0.474 ± 0.029	0.418 ± 0.041	1.657 ± 0.033	0.493 ± 0.033	0.211 ± 0.028
24233-1999 XD$_{94}$	J.Trojan	1	11.433 ± 0.071	9.103 ± 1.978	0.704 ± 0.051	0.481 ± 0.037	0.418 ± 0.069	—	—	—
24341-2000 AJ$_{87}$	J.Trojan	1	12.013 ± 0.067	2.026 ± 1.928	0.713 ± 0.043	0.369 ± 0.035	0.390 ± 0.067	—	—	—
24380-2000 AA$_{160}$	J.Trojan	1	—	1.556 ± 1.804	0.734 ± 0.055	0.391 ± 0.048	0.336 ± 0.068	—	—	—
24390-2000 AD$_{177}$	J.Trojan	2	11.595 ± 0.066	12.512 ± 1.913	0.700 ± 0.042	0.513 ± 0.034	0.462 ± 0.066	1.684 ± 0.048	0.461 ± 0.055	0.140 ± 0.052
24420-2000 BU$_{22}$	J.Trojan	1	—	2.931 ± 1.742	0.937 ± 0.066	0.441 ± 0.042	0.304 ± 0.063	—	—	—
24426-2000 CR$_{12}$	J.Trojan	1	—	5.604 ± 1.660	0.717 ± 0.054	0.414 ± 0.043	0.424 ± 0.062	—	—	—
24444-2000 OP$_{32}$	J.Trojan	1	11.395 ± 0.093	6.264 ± 2.536	0.712 ± 0.071	0.437 ± 0.053	0.409 ± 0.090	—	—	—
24452-2000 QU$_{167}$	J.Trojan	1	11.776 ± 0.099	6.333 ± 2.377	0.872 ± 0.056	0.441 ± 0.056	0.406 ± 0.087	—	—	—
24467-2000 SS$_{165}$	J.Trojan	1	11.800 ± 0.104	11.221 ± 2.463	0.927 ± 0.079	0.460 ± 0.060	0.513 ± 0.091	—	—	—
24835-1995 SM$_{55}$	Classic Hot	10	4.332 ± 0.040	0.272 ± 1.805	0.652 ± 0.032	0.357 ± 0.043	0.356 ± 0.052	1.010 ± 0.050	-0.270 ± 0.163	—
24952-1997 QJ$_{4}$	Res. 3:2	4	7.622 ± 0.194	4.696 ± 4.772	0.763 ± 0.114	0.431 ± 0.114	0.396 ± 0.102	—	—	—
24978-1998 HJ$_{151}$	Classic Cold	2	7.008 ± 0.050	29.628 ± 2.427	1.110 ± 0.030	0.710 ± 0.030	—	—	—	—
25347-1999 RQ$_{116}$	J.Trojan	1	11.545 ± 0.075	10.900 ± 2.252	0.618 ± 0.058	0.488 ± 0.042	0.461 ± 0.079	—	—	—
26181-1996 GQ$_{21}$	Res.(other)	8	4.796 ± 0.051	37.628 ± 1.969	1.011 ± 0.068	0.726 ± 0.043	0.694 ± 0.056	2.438 ± 0.062	0.497 ± 0.082	0.055 ± 0.096
26308-1998 SM$_{165}$	Res.(other)	8	5.549 ± 0.107	31.425 ± 2.295	0.989 ± 0.114	0.641 ± 0.056	0.666 ± 0.072	2.295 ± 0.087	0.546 ± 0.086	0.080 ± 0.071
26308-1998 SM$_{165+B}$	Res.(other)	1	—	31.037 ± 0.000	—	—	—	—	—	—

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
26375-1999 DE$_{9}$	Res.(other)	13	4.809 ± 0.045	20.625 ± 1.625	0.967 ± 0.043	0.579 ± 0.036	0.568 ± 0.043	1.717 ± 0.193	0.327 ± 0.106	0.025 ± 0.108
28958-2001 CQ$_{42}$	J.Trojan	1	—	-2.591 ± 1.987	0.730 ± 0.054	0.364 ± 0.045	0.230 ± 0.071	—	—	—
28978-Ixion	Res. 3:2	8	3.429 ± 0.050	22.481 ± 2.259	1.009 ± 0.051	0.610 ± 0.030	0.580 ± 0.040	1.590 ± 0.064	0.277 ± 0.069	-0.010 ± 0.071
29981-1999 TD$_{10}$	Scattered	18	8.693 ± 0.039	12.194 ± 1.263	0.808 ± 0.095	0.502 ± 0.032	0.511 ± 0.051	1.790 ± 0.057	0.425 ± 0.093	—
30698-Hippokoon	J.Trojan	3	11.977 ± 0.125	7.486 ± 2.170	0.715 ± 0.067	0.458 ± 0.048	0.412 ± 0.079	1.527 ± 0.074	0.396 ± 0.080	0.183 ± 0.069
31820-1999 RT$_{186}$	J.Trojan	1	12.450 ± 0.168	10.495 ± 4.232	0.889 ± 0.093	0.520 ± 0.091	0.396 ± 0.153	—	—	—
31821-1999 RK$_{225}$	J.Trojan	1	11.849 ± 0.173	8.202 ± 3.877	0.980 ± 0.111	0.440 ± 0.097	0.461 ± 0.145	—	—	—
31824-Elatus	Centaurs	14	10.462 ± 0.122	27.348 ± 1.859	1.020 ± 0.060	0.620 ± 0.048	0.630 ± 0.038	—	0.392 ± 0.062	0.020 ± 0.086
32430-2000 RQ$_{83}$	J.Trojan	1	12.293 ± 0.074	8.679 ± 1.818	0.772 ± 0.038	0.474 ± 0.045	0.425 ± 0.067	—	—	—
32532-Thereus	Centaurs	221	9.218 ± 0.015	10.537 ± 1.186	0.763 ± 0.072	0.501 ± 0.016	0.488 ± 0.036	1.350 ± 0.050	0.442 ± 0.074	0.110 ± 0.074
32615-2001 QU$_{277}$	J.Trojan	1	11.405 ± 0.050	9.346 ± 1.235	0.807 ± 0.052	0.452 ± 0.028	0.474 ± 0.043	—	—	—
32794-1989 UE$_{5}$	J.Trojan	1	12.744 ± 0.094	6.794 ± 2.116	0.923 ± 0.065	0.393 ± 0.056	0.486 ± 0.080	—	—	—
32929-1995 QY$_{9}$	Classic Cold	5	7.365 ± 0.062	18.741 ±10.170	0.740 ± 0.200	0.561 ± 0.110	—	2.027 ± 0.201	—	—
33001-1997 CU$_{29}$	Classic Cold	6	6.216 ± 0.104	28.823 ± 3.429	1.157 ± 0.145	0.645 ± 0.066	0.634 ± 0.092	—	0.410 ± 0.238	—
33128-1998 BU$_{48}$	Scattered	9	6.861 ± 0.137	26.535 ± 4.487	1.044 ± 0.071	0.631 ± 0.101	0.644 ± 0.104	2.275 ± 0.059	0.505 ± 0.098	-0.157 ± 0.105
33340-1998 VG$_{44}$	Res. 3:2	12	6.322 ± 0.073	20.986 ± 3.166	0.930 ± 0.055	0.573 ± 0.047	0.598 ± 0.098	—	0.398 ± 0.128	0.010 ± 0.078
34785-2001 RG$_{87}$	J.Trojan	1	12.513 ± 0.076	4.113 ± 1.599	0.728 ± 0.050	0.386 ± 0.043	0.419 ± 0.060	—	—	—
35671-1998 SN$_{165}$	Classic Cold	6	5.679 ± 0.320	6.857 ± 3.068	0.712 ± 0.095	0.444 ± 0.078	0.437 ± 0.083	1.270 ± 0.050	—	—
38083-Rhadamanth	Classic Hot	1	7.430 ± 0.063	11.286 ± 3.072	0.650 ± 0.085	0.527 ± 0.069	0.412 ± 0.075	—	—	—
38084-1999 HB$_{12}$	Res.(other)	3	6.632 ± 0.079	15.815 ± 3.668	0.893 ± 0.064	0.544 ± 0.065	0.481 ± 0.094	—	—	—
38628-Huya	Res. 3:2	58	4.678 ± 0.099	22.400 ± 2.192	0.963 ± 0.042	0.609 ± 0.090	0.593 ± 0.055	1.970 ± 0.050	0.330 ± 0.109	—
39285-2001 BP$_{75}$	J.Trojan	1	—	-0.195 ± 1.869	0.810 ± 0.059	0.381 ± 0.044	0.291 ± 0.067	—	—	—
40314-1999 KR$_{16}$	Scattered	5	5.612 ± 0.092	42.033 ± 2.385	1.123 ± 0.083	0.738 ± 0.057	0.750 ± 0.040	—	0.560 ± 0.071	0.020 ± 0.071
42301-2001 UR$_{163}$	Res.(other)	6	3.799 ± 0.102	44.811 ± 2.993	1.290 ± 0.109	0.840 ± 0.048	0.673 ± 0.121	2.381 ± 0.058	0.476 ± 0.115	—
42355-Typhon	Scattered	12	7.252 ± 0.054	12.657 ± 1.354	0.758 ± 0.039	0.525 ± 0.022	0.414 ± 0.053	1.560 ± 0.045	0.406 ± 0.087	0.160 ± 0.071
42355-Typhon+B	Scattered	1	—	9.763 ± 0.000	—	—	—	—	—	—
43212-2000 AL$_{113}$	J.Trojan	1	—	2.314 ± 1.748	—	0.402 ± 0.043	0.343 ± 0.064	—	—	—
44594-1999 OX$_{3}$	Scattered	30	7.052 ± 0.085	34.216 ± 2.104	1.138 ± 0.067	0.705 ± 0.056	0.642 ± 0.066	2.217 ± 0.127	0.399 ± 0.105	-0.023 ± 0.090
45802-2000 PV$_{29}$	Classic Cold	2	—	—	—	—	—	—	0.428 ± 0.291	—
47171-1999 TC$_{36}$	Res. 3:2	23	4.858 ± 0.060	29.334 ± 1.738	1.029 ± 0.047	0.693 ± 0.032	0.619 ± 0.049	2.215 ± 0.101	0.337 ± 0.092	0.009 ± 0.090
47171-1999 TC$_{36+B}$	Res. 3:2	1	—	19.177 ± 0.000	—	—	—	—	—	—
47932-2000 GN$_{171}$	Res. 3:2	13	6.183 ± 0.045	26.540 ± 1.817	0.924 ± 0.059	0.622 ± 0.038	0.617 ± 0.054	1.711 ± 0.079	0.365 ± 0.108	0.060 ± 0.099
47967-2000 SL$_{298}$	J.Trojan	1	11.843 ± 0.113	11.415 ± 2.726	0.899 ± 0.058	0.489 ± 0.069	0.476 ± 0.102	—	—	—
48249-2001 SY$_{345}$	J.Trojan	1	12.550 ± 0.072	11.716 ± 1.707	0.758 ± 0.050	0.530 ± 0.037	0.420 ± 0.060	—	—	—
48252-2001 TL$_{212}$	J.Trojan	1	12.719 ± 0.153	8.694 ± 3.314	0.949 ± 0.100	0.467 ± 0.093	0.436 ± 0.129	—	—	—
48639-1995 TL$_{8}$	Scattered	4	4.664 ± 0.087	22.529 ± 6.004	1.008 ± 0.159	0.621 ± 0.091	0.551 ± 0.120	2.420 ± 0.050	0.412 ± 0.131	-0.020 ± 0.085

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
49036-Pelion	Centaurs	3	10.420 ± 0.247	8.735 ± 3.519	0.746 ± 0.080	0.556 ± 0.078	0.368 ± 0.102	—	—	—
50000-Quaoar	Classic Hot	4	2.220 ± 0.029	29.224 ± 1.706	0.958 ± 0.035	0.650 ± 0.020	0.610 ± 0.028	2.180 ± 0.058	0.360 ± 0.050	0.030 ± 0.057
51359-2000 SC$_{17}$	J.Trojan	1	11.985 ± 0.233	7.745 ± 5.725	0.864 ± 0.201	0.447 ± 0.131	0.438 ± 0.210	—	—	—
52747-1998 HM$_{151}$	Classic Cold	1	7.417 ± 0.100	24.891 ± 4.691	0.930 ± 0.090	0.620 ± 0.050	—	—	—	—
52872-Okyrhoe	Centaurs	18	10.768 ± 0.093	10.846 ± 2.450	0.743 ± 0.065	0.486 ± 0.061	0.474 ± 0.070	—	0.457 ± 0.068	0.159 ± 0.080
52975-Cyllarus	Centaurs	9	8.634 ± 0.100	32.286 ± 3.654	1.096 ± 0.095	0.680 ± 0.085	0.669 ± 0.090	2.425 ± 0.077	0.450 ± 0.092	-0.100 ± 0.085
53469-2000 AX$_{8}$	J.Trojan	1	—	0.771 ± 1.818	0.663 ± 0.051	0.356 ± 0.045	0.361 ± 0.067	—	—	—
54520-2000 PJ$_{30}$	Scattered	1	—	—	—	—	—	—	0.410 ± 0.304	—
54598-Bienor	Centaurs	15	7.573 ± 0.104	8.793 ± 2.427	0.711 ± 0.059	0.476 ± 0.046	0.400 ± 0.079	1.684 ± 0.091	0.379 ± 0.078	0.153 ± 0.099
55565-2002 AW$_{197}$	Classic Hot	9	3.087 ± 0.038	22.129 ± 1.429	0.913 ± 0.041	0.602 ± 0.031	0.581 ± 0.037	1.740 ± 0.054	0.329 ± 0.070	0.215 ± 0.094
55576-Amycus	Centaurs	19	7.774 ± 0.047	33.885 ± 1.517	1.112 ± 0.041	0.702 ± 0.030	0.668 ± 0.039	—	0.299 ± 0.077	0.004 ± 0.064
55636-2002 TX$_{300}$	Classic Hot	8	3.237 ± 0.043	-0.195 ± 1.513	0.679 ± 0.038	0.359 ± 0.024	0.323 ± 0.041	—	—	—
55637-2002 UX$_{25}$	Classic Hot	8	3.497 ± 0.020	15.518 ± 1.290	1.007 ± 0.043	0.540 ± 0.030	—	—	0.404 ± 0.049	—
55638-2002 VE$_{95}$	Res. 3:2	2	—	36.638 ± 2.876	1.127 ± 0.074	—	—	2.220 ± 0.057	0.400 ± 0.057	0.020 ± 0.064
56968-2000 SA$_{92}$	J.Trojan	1	11.534 ± 0.059	13.013 ± 1.374	0.986 ± 0.040	0.494 ± 0.033	0.509 ± 0.049	—	—	—
58534-Logos	Classic Cold	7	6.758 ± 0.181	26.351 ± 4.789	0.990 ± 0.127	0.729 ± 0.120	0.602 ± 0.119	—	0.498 ± 0.340	—
58534-Logos+B	Classic Cold	1	—	17.578 ± 0.000	—	—	—	—	—	—
59358-1999 CL$_{158}$	Scattered	1	6.653 ± 0.090	5.546 ± 2.064	0.800 ± 0.060	0.390 ± 0.040	0.470 ± 0.060	—	—	—
60454-2000 CH$_{105}$	Classic Cold	2	6.376 ± 0.093	25.350 ± 3.158	1.019 ± 0.086	0.643 ± 0.096	0.583 ± 0.095	—	—	—
60458-2000 CM$_{114}$	Detached	2	6.972 ± 0.040	11.545 ± 1.858	0.730 ± 0.020	0.500 ± 0.020	—	—	—	—
60458-2000 CM$_{114+B}$	Detached	1	—	13.041 ± 0.000	—	—	—	—	—	—
60558-Echeclus	Centaurs	8	9.555 ± 0.155	10.399 ± 3.404	0.854 ± 0.081	0.465 ± 0.076	0.486 ± 0.095	1.480 ± 0.072	0.466 ± 0.125	0.340 ± 0.083
60608-2000 EE$_{173}$	Scattered	3	8.147 ± 0.180	13.198 ± 1.827	0.665 ± 0.032	0.488 ± 0.029	0.543 ± 0.056	—	—	—
60620-2000 FD$_{8}$	Res.(other)	3	6.507 ± 0.221	30.813 ± 3.016	1.151 ± 0.110	0.664 ± 0.078	0.648 ± 0.070	—	—	—
60621-2000 FE$_{8}$	Res.(other)	3	6.510 ± 0.062	11.433 ± 1.500	0.750 ± 0.024	0.480 ± 0.020	0.500 ± 0.050	—	0.470 ± 0.277	—
63252-2001 BL$_{41}$	Centaurs	10	11.278 ± 0.063	13.807 ± 2.421	0.718 ± 0.049	0.509 ± 0.044	0.381 ± 0.160	—	0.365 ± 0.071	0.255 ± 0.101
65150-2002 CA$_{126}$	J.Trojan	1	—	3.241 ± 1.724	0.651 ± 0.051	0.377 ± 0.044	0.407 ± 0.064	—	—	—
65225-2002 EK$_{44}$	J.Trojan	1	—	1.982 ± 1.783	0.693 ± 0.052	0.401 ± 0.044	0.334 ± 0.065	—	—	—
65489-Ceto	Scattered	3	6.286 ± 0.041	15.666 ± 0.871	0.860 ± 0.030	0.560 ± 0.030	—	—	—	—
65489-Ceto+B	Scattered	1	—	13.527 ± 0.000	—	—	—	—	—	—
66452-1999 OF$_{4}$	Classic Cold	3	6.323 ± 0.080	26.708 ± 3.878	1.032 ± 0.106	0.673 ± 0.083	0.601 ± 0.080	—	0.380 ± 0.253	—
66652-Borasisi	Classic Cold	7	5.418 ± 0.056	33.830 ± 2.714	0.820 ± 0.170	0.646 ± 0.058	0.647 ± 0.062	2.010 ± 0.067	0.457 ± 0.162	0.100 ± 0.094
66652-Borasisi+B	Classic Cold	1	—	41.482 ± 0.000	—	—	—	—	—	—
69986-1998 WW$_{24}$	Res. 3:2	3	7.963 ± 0.085	17.966 ± 2.895	0.756 ± 0.112	0.463 ± 0.081	0.659 ± 0.104	—	—	—
69987-1998 WA$_{25}$	Classic Cold	1	—	17.056 ± 0.000	—	—	—	—	—	—
69988-1998 WA$_{31}$	Res.(other)	2	7.352 ± 0.122	13.652 ± 6.704	0.786 ± 0.129	0.492 ± 0.133	0.530 ± 0.183	—	—	—

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
69990-1998 WU$_{31}$	Res. 3:2	1	8.204 ± 0.073	23.278 ± 3.272	0.720 ± 0.089	0.505 ± 0.086	0.722 ± 0.087	—	—	—
73480-2002 PN$_{34}$	Scattered	10	8.506 ± 0.030	12.613 ± 1.134	0.818 ± 0.095	0.520 ± 0.020	—	—	0.425 ± 0.105	—
76804-2000 QE	J.Trojan	1	12.095 ± 0.135	7.871 ± 2.878	0.803 ± 0.082	0.446 ± 0.070	0.443 ± 0.106	—	—	—
79360-1997 CS$_{29}$	Classic Cold	15	4.990 ± 0.060	28.475 ± 2.382	1.055 ± 0.079	0.666 ± 0.054	0.609 ± 0.057	2.073 ± 0.134	0.356 ± 0.150	0.104 ± 0.176
79360-1997 CS$_{29+B}$	Classic Cold	1	—	31.690 ± 0.000	—	—	—	—	—	—
79978-1999 CC$_{158}$	Res.(other)	2	5.355 ± 0.097	24.869 ± 2.974	0.996 ± 0.066	0.611 ± 0.052	0.619 ± 0.075	—	—	—
79983-1999 DF$_{9}$	Classic Hot	1	5.797 ± 0.110	33.944 ± 2.164	0.920 ± 0.060	0.710 ± 0.050	0.650 ± 0.060	—	—	—
80806-2000 CM$_{105}$	Classic Cold	2	—	32.348 ± 0.000	—	—	—	—	0.360 ± 0.256	—
82075-2000 YW$_{134}$	Res.(other)	14	4.382 ± 0.046	16.483 ± 2.187	0.922 ± 0.053	0.503 ± 0.052	0.581 ± 0.059	—	0.358 ± 0.153	—
82155-2001 FZ$_{173}$	Scattered	9	5.813 ± 0.024	15.975 ± 1.446	0.864 ± 0.023	0.546 ± 0.026	0.508 ± 0.036	—	0.171 ± 0.118	—
82158-2001 FP$_{185}$	Scattered	7	5.947 ± 0.054	16.009 ± 2.281	0.820 ± 0.048	0.572 ± 0.038	0.458 ± 0.078	—	—	—
83982-Crantor	Centaurs	17	8.662 ± 0.056	39.225 ± 1.992	1.105 ± 0.042	0.761 ± 0.039	0.667 ± 0.055	—	0.380 ± 0.067	-0.140 ± 0.064
84522-2002 TC$_{302}$	Res.(other)	2	3.719 ± 0.020	28.979 ± 1.356	1.120 ± 0.028	0.640 ± 0.020	0.660 ± 0.020	—	—	—
84709-2002 VW$_{120}$	J.Trojan	1	12.446 ± 0.158	12.795 ± 3.419	0.855 ± 0.087	0.462 ± 0.090	0.548 ± 0.130	—	—	—
85627-1998 HP$_{151}$	Classic Cold	1	—	25.429 ± 0.000	—	—	—	—	—	—
85633-1998 KR$_{65}$	Classic Cold	4	6.596 ± 0.206	30.583 ± 2.821	1.095 ± 0.080	0.628 ± 0.066	0.790 ± 0.081	—	—	—
86047-1999 OY$_{3}$	Classic Hot	5	6.396 ± 0.147	-3.527 ± 2.148	0.726 ± 0.037	0.345 ± 0.046	0.277 ± 0.076	—	-0.380 ± 0.256	—
86177-1999 RY$_{215}$	Classic Hot	3	7.429 ± 0.077	3.839 ± 3.476	0.719 ± 0.123	0.358 ± 0.090	0.631 ± 0.185	—	0.470 ± 0.286	—
87269-2000 OO$_{67}$	Scattered	3	9.027 ± 0.155	26.481 ± 2.592	1.080 ± 0.092	0.654 ± 0.081	0.593 ± 0.055	—	—	—
87555-2000 QB$_{243}$	Scattered	6	8.437 ± 0.129	5.554 ± 5.948	0.763 ± 0.086	0.383 ± 0.083	0.729 ± 0.198	1.480 ± 0.108	0.592 ± 0.152	—
88269-2001 KF$_{77}$	Centaurs	1	10.038 ± 0.020	37.355 ± 1.301	1.080 ± 0.040	0.730 ± 0.010	—	—	—	—
88611-Teharonhia	Classic Cold	1	—	5.020 ± 0.000	—	—	—	—	—	—
88611-Teharonhia+B	Classic Cold	1	—	4.612 ± 0.000	—	—	—	—	—	—
90377-Sedna	Detached	3	1.077 ± 0.065	32.954 ± 2.972	1.131 ± 0.079	0.686 ± 0.077	0.657 ± 0.067	2.320 ± 0.060	0.290 ± 0.222	0.050 ± 0.314
90482-Orcus	Res. 3:2	6	1.982 ± 0.099	2.761 ± 1.831	0.664 ± 0.041	0.370 ± 0.039	0.390 ± 0.045	1.070 ± 0.042	0.120 ± 0.051	0.053 ± 0.055
90568-2004 GV$_{9}$	Classic Hot	2	—	20.819 ± 1.099	0.843 ± 0.028	—	—	1.570 ± 0.058	0.340 ± 0.094	0.140 ± 0.094
91133-1998 HK$_{151}$	Res. 3:2	6	6.940 ± 0.075	9.775 ± 2.589	0.645 ± 0.121	0.520 ± 0.062	0.390 ± 0.061	1.570 ± 0.092	—	—
91205-1998 US$_{43}$	Res. 3:2	2	7.851 ± 0.078	4.463 ± 3.403	0.691 ± 0.102	0.446 ± 0.095	0.347 ± 0.094	—	—	—
91554-1999 RZ$_{215}$	Scattered	1	8.069 ± 0.079	19.081 ± 3.401	0.771 ± 0.097	0.575 ± 0.090	0.539 ± 0.091	—	—	—
95626-2002 GZ$_{32}$	Centaurs	18	6.733 ± 0.156	16.992 ± 2.947	0.674 ± 0.043	0.576 ± 0.054	0.538 ± 0.067	—	0.442 ± 0.113	—
99328-2001 UY$_{123}$	J.Trojan	1	12.610 ± 0.103	12.496 ± 2.292	0.890 ± 0.058	0.537 ± 0.056	0.434 ± 0.084	—	—	—
105685-2000 SC$_{51}$	J.Trojan	1	12.721 ± 0.097	8.131 ± 2.099	1.016 ± 0.055	0.444 ± 0.059	0.452 ± 0.081	—	—	—
111113-2001 VK$_{85}$	J.Trojan	1	12.760 ± 0.086	13.245 ± 1.864	0.822 ± 0.063	0.462 ± 0.048	0.558 ± 0.069	—	—	—
118228-1996 TQ$_{66}$	Res. 3:2	7	7.245 ± 0.195	38.250 ± 4.976	1.186 ± 0.118	0.670 ± 0.096	0.746 ± 0.113	2.435 ± 0.128	—	—
118379-1999 HC$_{12}$	Classic Hot	3	7.856 ± 0.125	12.620 ± 6.899	0.894 ± 0.163	0.490 ± 0.138	0.343 ± 0.125	—	0.490 ± 0.298	—
118702-2000 OM$_{67}$	Detached	1	7.075 ± 0.030	14.444 ± 1.982	0.820 ± 0.057	0.470 ± 0.040	0.590 ± 0.040	—	—	—

Table A.1. continued.

Object	Class[1]	Epochs[2]	M11 ±σ	Grt ±σ	B-V ±σ	V-R ±σ	R-I ±σ	V-J ±σ	J-H ±σ	H-K ±σ
119068-2001 KC$_{77}$	Res.(other)	1	6.822 ± 0.030	18.607 ± 1.301	0.910 ± 0.010	0.560 ± 0.010	—	—	—	—
119070-2001 KP$_{77}$	Res.(other)	1	—	—	—	—	—	—	0.370 ± 0.235	—
119315-2001 SQ$_{73}$	Centaurs	1	8.885 ± 0.030	8.875 ± 1.301	0.670 ± 0.020	0.460 ± 0.010	—	—	—	—
119951-2002 KX$_{14}$	Classic Cold	3	—	26.057 ± 1.557	1.050 ± 0.030	0.610 ± 0.020	—	—	—	—
119979-2002 WC$_{19}$	Res.(other)	1	—	28.487 ± 0.000	—	—	—	—	—	—
120061-2003 CO$_{1}$	Centaurs	11	9.208 ± 0.040	11.701 ± 2.057	0.740 ± 0.030	0.490 ± 0.020	—	—	0.326 ± 0.091	—
120132-2003 FY$_{128}$	Detached	3	4.476 ± 0.010	21.441 ± 1.266	1.050 ± 0.028	0.600 ± 0.020	0.550 ± 0.030	1.640 ± 0.058	0.360 ± 0.078	0.110 ± 0.085
120178-2003 OP$_{32}$	Classic Hot	1	—	3.135 ± 2.090	0.698 ± 0.052	—	—	—	—	—
120347-Salacia	Classic Hot	1	—	7.116 ± 0.000	—	—	—	—	—	—
120347-Salacia+B	Classic Hot	1	—	7.982 ± 0.000	—	—	—	—	—	—
120348-2004 TY$_{364}$	Res. 3:2	1	—	28.425 ± 3.958	1.059 ± 0.089	—	—	—	—	—
120453-1988 RE$_{12}$	J.Trojan	1	13.202 ± 0.189	6.453 ± 3.884	0.826 ± 0.132	0.388 ± 0.108	0.483 ± 0.151	—	—	—
121725-1999 XX$_{143}$	Centaurs	10	8.522 ± 0.123	30.600 ± 5.205	1.060 ± 0.089	0.648 ± 0.116	0.679 ± 0.123	—	—	—
123509-2000 WK$_{183}$	Classic Cold	1	—	29.751 ± 0.000	—	—	—	—	—	—
123509-2000 WK$_{183+B}$	Classic Cold	1	—	26.029 ± 0.000	—	—	—	—	—	—
124729-2001 SB$_{173}$	J.Trojan	1	12.556 ± 0.107	10.320 ± 2.774	0.992 ± 0.060	0.503 ± 0.064	0.424 ± 0.101	—	—	—
127546-2002 XU$_{93}$	Scattered	1	7.943 ± 0.010	5.447 ± 1.087	0.760 ± 0.028	0.440 ± 0.020	0.380 ± 0.020	—	—	—
129772-1999 HR$_{11}$	Classic Cold	1	—	28.264 ± 4.298	0.920 ± 0.120	0.530 ± 0.100	0.800 ± 0.070	—	—	—
130391-2000 JG$_{81}$	Res.(other)	1	7.755 ± 0.115	3.743 ± 4.431	—	0.370 ± 0.128	0.430 ± 0.134	—	—	—
131695-2001 XS$_{254}$	Res.(other)	1	—	—	—	—	—	—	0.420 ± 0.260	—
134340-Pluto	Res. 3:2	4	-0.881 ± 0.400	7.607 ± 0.681	0.867 ± 0.016	0.515 ± 0.035	0.400 ± 0.010	—	—	—
134340-Pluto+B	Res. 3:2	1	—	3.334 ± 0.000	0.710 ± 0.002	—	—	—	—	—
134340-Pluto+C	Res. 3:2	1	—	-2.234 ± 0.000	0.644 ± 0.028	—	—	—	—	—
134340-Pluto+D	Res. 3:2	1	—	18.074 ± 0.000	0.907 ± 0.031	—	—	—	—	—
134860-2000 OJ$_{67}$	Classic Cold	5	6.001 ± 0.120	26.378 ± 3.102	1.050 ± 0.060	0.670 ± 0.050	0.600 ± 0.070	—	0.305 ± 0.162	0.070 ± 0.139
134860-2000 OJ$_{67+B}$	Classic Cold	1	—	33.683 ± 0.000	—	—	—	—	—	—
135182-2001 QT$_{322}$	Classic Cold	1	—	15.584 ±11.076	0.710 ± 0.060	0.530 ± 0.120	—	—	—	—
136108-Haumea	Classic Hot	3	0.217 ± 0.030	-0.010 ± 0.850	0.631 ± 0.025	0.370 ± 0.020	0.320 ± 0.020	1.051 ± 0.020	-0.044 ± 0.037	-0.111 ± 0.048
136199-Eris	Detached	64	-1.462 ± 0.036	3.866 ± 0.823	0.805 ± 0.015	0.389 ± 0.049	0.363 ± 0.061	0.849 ± 0.108	0.080 ± 0.072	-0.280 ± 0.085
136472-Makemake	Classic Hot	1	—	4.693 ± 0.900	0.828 ± 0.022	—	—	—	—	—
137294-1999 RE$_{215}$	Classic Cold	3	6.415 ± 0.187	30.557 ± 3.448	1.003 ± 0.130	0.710 ± 0.074	0.571 ± 0.089	—	—	—
137295-1999 RB$_{216}$	Res.(other)	1	7.670 ± 0.087	14.468 ± 2.704	0.897 ± 0.122	0.522 ± 0.073	0.506 ± 0.061	—	—	—
138537-2000 OK$_{67}$	Classic Cold	5	6.082 ± 0.083	20.354 ± 3.262	0.821 ± 0.123	0.583 ± 0.072	0.524 ± 0.079	2.421 ± 0.088	0.455 ± 0.145	0.040 ± 0.078
144897-2004 UX$_{10}$	Res. 3:2	1	—	20.664 ± 2.909	0.950 ± 0.020	0.580 ± 0.030	—	—	—	—
145451-2005 RM$_{43}$	Scattered	2	—	1.330 ± 1.474	0.590 ± 0.038	—	—	0.910 ± 0.067	0.200 ± 0.085	0.280 ± 0.092
145452-2005 RN$_{43}$	Classic Hot	2	—	16.523 ±-9.000	—	—	—	1.550 ± 0.058	0.310 ± 0.071	0.190 ± 0.071

Table A.1. continued.

Object	Class[(1)]	Epochs[(2)]	M11 $\pm\sigma$	Grt $\pm\sigma$	B-V $\pm\sigma$	V-R $\pm\sigma$	R-I $\pm\sigma$	V-J $\pm\sigma$	J-H $\pm\sigma$	H-K $\pm\sigma$
145453-2005 RR$_{43}$	Classic Hot	3	—	0.109 ± 3.025	0.790 ± 0.076	—	—	1.020 ± 0.067	—	—
145480-2005 TB$_{190}$	Detached	1	4.169 ± 0.020	18.632 ± 1.525	0.980 ± 0.042	0.560 ± 0.030	0.550 ± 0.030	—	—	—
148209-2000 CR$_{105}$	Detached	3	6.228 ± 0.040	14.424 ± 3.398	0.771 ± 0.082	0.509 ± 0.048	0.590 ± 0.090	—	0.410 ± 0.297	—
148780-Altjira	Classic Hot	1	—	29.751 ± 0.000	—	—	—	—	—	—
148780-Altjira+B	Classic Hot	1	—	35.732 ± 0.000	—	—	—	—	—	—
150642-2001 CZ$_{31}$	Classic Hot	1	—	—	—	—	—	—	0.550 ± 0.099	0.160 ± 0.099
163135-2002 CT$_{22}$	J.Trojan	1	—	1.927 ± 1.789	0.690 ± 0.053	0.382 ± 0.045	0.360 ± 0.066	—	—	—
163216-2002 EN$_{68}$	J.Trojan	1	—	4.392 ± 1.713	—	0.443 ± 0.042	0.347 ± 0.062	—	—	—
168700-2000 GE$_{147}$	Res. 3:2	1	8.002 ± 0.110	16.667 ± 3.950	—	0.550 ± 0.120	0.520 ± 0.114	—	—	—
168703-2000 GP$_{183}$	Classic Cold	5	5.756 ± 0.060	8.353 ± 2.654	0.669 ± 0.074	0.445 ± 0.053	0.463 ± 0.066	—	—	—
181708-1993 FW	Classic Hot	8	6.527 ± 0.122	18.980 ± 3.484	1.023 ± 0.069	0.583 ± 0.070	0.439 ± 0.104	—	0.400 ± 0.250	—
181855-1998 WT$_{31}$	Classic Hot	3	7.440 ± 0.088	10.112 ± 6.721	0.751 ± 0.144	0.502 ± 0.121	0.416 ± 0.166	—	—	—
181867-1999 CV$_{118}$	Res.(other)	1	7.186 ± 0.063	31.744 ± 2.469	—	0.733 ± 0.067	0.582 ± 0.062	—	—	—
181871-1999 CO$_{153}$	Classic Cold	1	—	38.554 ± 0.000	—	—	—	—	—	—
181874-1999 HW$_{11}$	Detached	2	6.672 ± 0.077	12.562 ± 2.766	0.840 ± 0.042	0.499 ± 0.073	0.493 ± 0.083	—	—	—
181902-1999 RD$_{215}$	Detached	2	7.860 ± 0.079	7.547 ± 0.000	—	—	0.498 ± 0.058	—	—	—
182397-2001 QW$_{297}$	Classic Hot	1	6.660 ± 0.050	25.220 ± 3.210	1.020 ± 0.099	0.580 ± 0.070	0.670 ± 0.060	—	—	—
182933-2002 GZ$_{31}$	Detached	1	—	33.013 ± 0.000	—	—	—	—	—	—
192388-1996 RD$_{29}$	J.Trojan	1	—	4.691 ± 1.684	0.741 ± 0.055	0.421 ± 0.042	0.388 ± 0.062	—	—	—
192929-2000 AT$_{44}$	J.Trojan	1	—	-0.624 ± 1.876	0.707 ± 0.053	0.354 ± 0.045	0.318 ± 0.068	—	—	—
208996-2003 AZ$_{84}$	Res. 3:2	9	3.227 ± 0.050	23.884 ± 2.812	0.757 ± 0.146	0.620 ± 0.030	0.560 ± 0.042	1.210 ± 0.054	0.188 ± 0.165	0.060 ± 0.071

List of Objects

Table A.2. References used for each object, and number of epochs.

Object	References	Nr.
C/1983 H1 IRAS-Araki-Alcock	Lamy et al. (2004)	1
C/1983 J1 Sugano-Saigusa-Fujikawa	Lamy et al. (2004)	1
C/1984 K1 Shoemaker	Lamy et al. (2004)	1
C/1984 U1 Shoemaker	Lamy et al. (2004)	1
C/1986 P1 Wilson	Lamy et al. (2004)	1
C/1987 A1 Levy	Lamy et al. (2004)	1
C/1987 H1 Shoemaker	Lamy et al. (2004)	1
C/1988 B1 Shoemaker	Lamy et al. (2004)	1
C/1988 C1 Maury-Phinney	Lamy et al. (2004)	1
C/1995 O1 Hale-Bopp	Lamy and Toth (2009)	
	Lamy et al. (2004)	2
C/1996 B2 Hyakutake	Lamy et al. (2004)	1
C/1999 S4 LINEAR	Lamy et al. (2004)	1
C/2000 B4 LINEAR	Bauer et al. (2003)	6
C/2001 M10 NEAT	Jewitt (2009b)	2
C/2001 OG108 LONEOS	Lamy et al. (2004)	1
P/1991 L3 Levy	Lamy et al. (2004)	1
P/1993 W1 Mueller	Lamy et al. (2004)	1
P/1994 A1 Kushida	Lamy et al. (2004)	1
P/1994 J3 Shoemaker	Lamy et al. (2004)	1
P/1995 A1 Jedicke	Lamy et al. (2004)	1
P/1996 A1 Jedicke	Lamy et al. (2004)	1
P/1997 C1 Gehrels	Lamy et al. (2004)	1
P/1997 G1 Montani	Lamy et al. (2004)	1
P/1997 V1 Larsen	Lamy et al. (2004)	1
P/1998 S1 LM	Lamy et al. (2004)	1
P/1999 D1 Hermann	Lamy et al. (2004)	1
P/1999 RO28 LONEOS	Lamy et al. (2004)	1
P/2004 A1	Jewitt (2009b)	1
1P/Halley	Lamy et al. (2004)	
	Keller and Thomas (1989)	2
2P/Encke	Jewitt (2002b)	
	Meech et al. (2004)	
	Lamy et al. (2004)	
	Luu and Jewitt (1990)	6
4P/Faye	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
6P/d'Arrest	Meech et al. (2004)	
	Jewitt (2002b)	
	Lamy et al. (2004)	3
7P/Pons-Winnecke	Snodgrass et al. (2005)	
	Lamy et al. (2004)	2
8P/Tuttle	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
9P/Tempel 1	Meech et al. (2004)	
	Lamy et al. (2004)	14
10P/Tempel 2	Jewitt and Luu (1989)	
	Meech et al. (2004)	
	Lamy et al. (2004)	
	Jewitt and Meech (1988)	
	Lamy and Toth (2009)	10
14P/Wolf	Snodgrass et al. (2005)	
	Lamy et al. (2004)	2
15P/Finlay	Lamy et al. (2004)	1
16P/Brooks2	Lamy et al. (2004)	1
17P/Holmes	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
19P/Borrelly	Lamy et al. (2004)	1
21P/GZ	Lamy et al. (2004)	
	Luu (1993)	2
22P/Kopff	Meech et al. (2004)	
	Lamy et al. (2004)	
	Lamy et al. (2002)	
	Lamy and Toth (2009)	4
24P/Schaumasse	Lamy et al. (2004)	1
26P/GS	Boehnhardt et al. (1999)	
	Lamy et al. (2004)	2

Table A.2. Continued

Object	References	Nr.
28P/Neujmin 1	Jewitt and Meech (1988)	
	Delahodde et al. (2001)	
	Meech et al. (2004)	
	Lamy et al. (2004)	
	Campins et al. (1987)	11
29P/Schwassmann-Wachmann 1	Bauer et al. (2003)	
	Jewitt (2009b)	
	Lamy et al. (2004)	3
30P/Reinmuth1	Lamy et al. (2004)	1
31P/Schwassmann-Wachmann 2	Lamy et al. (2004)	1
32P/ComasSola	Lamy et al. (2004)	1
33P/Daniel	Lamy et al. (2004)	1
36P/Whipple	Lamy et al. (2004)	1
37P/Forbes	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
39P/Oterma	Bauer et al. (2003)	
	Jewitt (2009b)	
	Lamy et al. (2004)	3
40P/Vaisala 1	Lamy et al. (2004)	1
41P/Tuttle-Giacobini-Kresak	Lamy et al. (2004)	1
42P/Neujmin 3	Lamy et al. (2004)	1
43P/Wolf-Harrington	Lamy et al. (2004)	1
44P/Reinmuth 2	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
45P/Honda-Mrkos-Pajduŝáková	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
46P/Wirtanen	Meech et al. (2004)	
	Lamy et al. (2004)	
	Lamy and Toth (2009)	3
47P/Ashbrook-Jackson	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
48P/Johnson	Lamy et al. (2004)	1
49P/Arend-Rigaux	Lowry et al. (2003)	
	Lamy et al. (2004)	
	Millis et al. (1988)	3
50P/Arend	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
51P/Harrington	Lamy et al. (2004)	1
52P/Harrington-Abell	Lamy et al. (2004)	1
53P/Van Biesbroeck	Meech et al. (2004)	
	Lamy et al. (2004)	2
55P/Tempel-Tuttle	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
56P/Slaughter-Burnham	Lamy et al. (2004)	1
57P/du Toit-Neujmin-Delporte	Lamy et al. (2004)	1
58P/Jackson-Neujmin	Lamy et al. (2004)	1
59P/Kearns-Kwee	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
60P/Tsuchinshan 2	Lamy et al. (2004)	1
61P/Shajn-Schaldach	Lamy et al. (2004)	1
62P/Tsuchinshan 1	Lamy et al. (2004)	1
63P/Wild 1	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
64P/Swift-Gehrels	Lamy et al. (2004)	1
65P/Gunn	Lamy et al. (2004)	1
67P/Churyumov-Gerasimenko	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
68P/Klemola	Lamy et al. (2004)	1
69P/Taylor	Lamy et al. (2004)	1
70P/Kojima	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
71P/Clark	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
72P/Denning-Fujikawa	Lamy et al. (2004)	1
73P/Schwassmann-Wachmann 3	Boehnhardt et al. (1999)	1
73P/Schwassmann-Wachmann 3 C	Lamy et al. (2004)	1
74P/Smirnova-Chernykh	Lamy et al. (2004)	1

Table A.2. Continued

Object	References	Nr.
75P/Kohoutek	Lamy et al. (2004)	1
76P/West-Kohoutek-Ikemura	Lamy et al. (2004)	1
77P/Longmore	Lamy et al. (2004)	1
78P/Gehrels 2	Lamy et al. (2004)	1
79P/du Toit-Hartley	Lamy et al. (2004)	1
81P/Wild 2	Lamy et al. (2004)	1
82P/Gehrels 3	Lamy et al. (2004)	1
84P/Giclas	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
86P/Wild 3	Meech et al. (2004)	
	Lamy et al. (2004)	
	Lamy and Toth (2009)	3
87P/Bus	Meech et al. (2004)	
	Lamy et al. (2004)	2
88P/Howell	Lamy et al. (2004)	1
89P/Russell 2	Lamy et al. (2004)	1
90P/Gehrels 1	Lamy et al. (2004)	1
91P/Russell 3	Lamy et al. (2004)	1
92P/Sanguin	Snodgrass et al. (2005)	
	Lamy et al. (2004)	2
93P/Lovas 1	Meech et al. (2004)	1
94P/Russell 4	Lamy et al. (2004)	1
96P/Machholz 1	Meech et al. (2004)	
	Lamy et al. (2004)	2
97P/Metcalf-Brewington	Lamy et al. (2004)	1
98P/Takamizawa	Lamy et al. (2004)	1
99P/Kowal 1	Lamy et al. (2004)	1
100P/Hartley 1	Lamy et al. (2004)	1
101P/Chernykh	Lamy et al. (2004)	1
103P/Hartley 2	Lamy et al. (2004)	1
104P/Kowal 2	Lamy et al. (2004)	1
105P/Singer-Brewster	Lamy et al. (2004)	1
106P/Schuster	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
107P/Wilson-Harrington	Meech et al. (2004)	
	Lowry and Weissman (2003)	
	Lamy et al. (2004)	
	Chamberlin et al. (1996)	6
109P/Swift-Tuttle	Green et al. (1997)	
	Lamy et al. (2004)	2
110P/Hartley 3	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
111P/Helin-Roman-Crockett	Lamy et al. (2004)	1
112P/Urata-Niijima	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
113P/Spitaler	Lamy et al. (2004)	1
114P/Wiseman-Skiff	Lamy et al. (2004)	
	Lamy and Toth (2009)	2
115P/Maury	Lamy et al. (2004)	1
116P/Wild 4	Lamy et al. (2004)	1
117P/Helin-Roman-Alu 1	Lamy et al. (2004)	1
118P/Shoemaker-Levy 4	Lamy et al. (2004)	1
119P/Parker-Hartley	Lamy et al. (2004)	1
120P/Mueller 1	Lamy et al. (2004)	1
121P/Shoemaker-Holt 2	Lamy et al. (2004)	1
123P/West-Hartley	Lamy et al. (2004)	1
124P/Mrkos	Lamy et al. (2004)	1
125P/Spacewatch	Lamy et al. (2004)	1
126P/IRAS	Lamy et al. (2004)	1
128P/Shoemaker-Holt 1	Lamy et al. (2004)	1
129P/Shoemaker-Levy 3	Lamy et al. (2004)	1
130P/McNaught-Hughes	Lamy et al. (2004)	1
131P/Mueller 2	Lamy et al. (2004)	1
132P/Helin-Roman-Alu 2	Lamy et al. (2004)	1
134P/Koval-Vávrová	Lamy et al. (2004)	1
135P/Shoemaker-Levy 8	Lamy et al. (2004)	1
136P/Mueller 3	Lamy et al. (2004)	1
137P/Shoemaker-Levy 2	Lamy et al. (2004)	1
138P/Shoemaker-Levy 7	Lamy et al. (2004)	1
139P/Väisälä-Oterma	Lamy et al. (2004)	1

Table A.2. Continued

Object	References	Nr.
140P/BS	Lamy et al. (2004)	1
141P/Machholz2	Lamy et al. (2004)	1
143P/KM	Jewitt (2002b)	
	Jewitt et al. (2003)	
	Lamy et al. (2004)	5
144P/Kushida	Lamy et al. (2004)	1
147P/Kushida-Muramatsu	Lamy et al. (2004)	1
148P/Anderson-LINEAR	Lamy et al. (2004)	1
152P/Helin-Lawrence	Lamy et al. (2004)	1
154P/Brewington	Lamy et al. (2004)	1
166P/NEAT	Jewitt (2009b)	2
204P/Wild 2	Meech et al. (2004)	1
1172-Aneas	Fornasier (2007)	2
1173-Anchises	Fornasier (2007)	1
1647-Menelaus	Fornasier (2007)	1
1871-Astyanax	Fornasier (2007)	3
1993 RO	Boehnhardt et al. (2001)	
	Tegler and Romanishin (2000)	2
1994 ES_2	Green et al. (1997)	1
1994 EV_3	Boehnhardt et al. (2001)	
	Gil-Hutton and Licandro (2001)	
	Boehnhardt et al. (2002)	4
1994 TA	Tegler and Romanishin (2000)	
	Jewitt and Luu (2001)	2
1995 DB_2	Green et al. (1997)	
	Benecchi et al. (2011)	2
1995 DC_2	Green et al. (1997)	5
1995 FB_{21}	Green et al. (1997)	4
1995 HM_5	Romanishin and Tegler (1999)	
	Gil-Hutton and Licandro (2001)	
	Boehnhardt et al. (2001)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	
	Tegler and Romanishin (1998)	8
1995 WY_2	Jewitt and Luu (2001)	2
1996 KV_1	Benecchi et al. (2011)	1
1996 RQ_{20}	Romanishin and Tegler (1999)	
	Jewitt and Luu (2001)	
	Boehnhardt et al. (2001)	
	Delsanti et al. (2001)	
	Benecchi et al. (2011)	
	Tegler and Romanishin (1998)	7
1996 RR_{20}	Jewitt and Luu (2001)	
	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	4
1996 TC_{68}	Gil-Hutton and Licandro (2001)	1
1996 TK_{66}	Tegler and Romanishin (2000)	
	Jewitt and Luu (2001)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	4
1996 TS_{66}	Jewitt and Luu (1998)	
	Romanishin and Tegler (1999)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Tegler and Romanishin (1998)	7
1997 CT_{29}	Tegler and Romanishin (2000)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	4
1997 CV_{29}	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	2
1997 GA_{45}	Gladman et al. (1998)	1
1997 QH_4	Tegler and Romanishin (2000)	
	Jewitt and Luu (2001)	
	Delsanti et al. (2001)	
	Boehnhardt et al. (2002)	4
1997 RL_{13}	Gladman et al. (1998)	1

Table A.2. Continued

Object	References	Nr.
1997 RT_5	Gladman et al. (1998)	
	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	4
1997 RX_9	Gladman et al. (1998)	1
1997 SZ_{10}	Tegler and Romanishin (2000)	1
1998 FS_{144}	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	4
1998 KG_{62}	Gil-Hutton and Licandro (2001)	
	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2001)	5
1998 KS_{65}	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	2
1998 KY_{61}	Benecchi et al. (2011)	1
1998 UR_{43}	Gil-Hutton and Licandro (2001)	
	Delsanti et al. (2001)	
	Benecchi et al. (2011)	4
1998 UU_{43}	Benecchi et al. (2011)	2
1998 WS_{31}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	2
1998 WU_{24}	Davies et al. (2001)	1
1998 WV_{24}	Tegler and Romanishin (2000)	
	Benecchi et al. (2011)	2
1998 WV_{31}	Delsanti et al. (2001)	
	Peixinho et al. (2004)	2
1998 WW_{31}	Benecchi et al. (2009)	1
1998 WW_{31+B}	Benecchi et al. (2009)	1
1998 WX_{24}	Tegler and Romanishin (2000)	
	Benecchi et al. (2011)	2
1998 WX_{31}	Delsanti et al. (2001)	
	Benecchi et al. (2011)	3
1998 WY_{24}	Benecchi et al. (2011)	2
1998 WZ_{31}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	3
1998 XY_{95}	Boehnhardt et al. (2001)	
	Benecchi et al. (2011)	2
1999 CB_{119}	Peixinho et al. (2004)	1
1999 CD_{158}	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Delsanti et al. (2006)	
	Benecchi et al. (2011)	5
1999 CF_{119}	Delsanti et al. (2001)	
	Benecchi et al. (2011)	3
1999 CH_{119}	Benecchi et al. (2011)	1
1999 CJ_{119}	Benecchi et al. (2011)	1
1999 CL_{119}	Peixinho et al. (2004)	
	Benecchi et al. (2011)	2
1999 CQ_{133}	Benecchi et al. (2011)	1
1999 CX_{131}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	3
1999 HJ_{12}	Benecchi et al. (2011)	2
1999 HS_{11}	Tegler and Romanishin (2003)	
	Peixinho et al. (2004)	
	Doressoundiram et al. (2001)	3
1999 HV_{11}	Tegler and Romanishin (2003)	1
1999 OD_4	Benecchi et al. (2011)	1
1999 OE_4	Peixinho et al. (2004)	
	Benecchi et al. (2011)	4
1999 OH_4	Benecchi et al. (2011)	
	Snodgrass et al. (2010)	2
1999 OJ_4	Peixinho et al. (2004)	
	Benecchi et al. (2011)	
	Benecchi et al. (2009)	5
1999 OJ_{4+B}	Benecchi et al. (2009)	1
1999 OM_4	Boehnhardt et al. (2002)	1
1999 RC_{215}	Benecchi et al. (2011)	2

Table A.2. Continued

Object	References	Nr.
1999 RT_{214}	Benecchi et al. (2009)	1
1999 RX_{214}	Peixinho et al. (2004)	
	Benecchi et al. (2011)	3
1999 RY_{214}	Peixinho et al. (2004)	2
1999 TR_{11}	Tegler and Romanishin (2000)	
	Benecchi et al. (2011)	2
1999 XY_{143}	Benecchi et al. (2011)	1
2000 AF_{255}	Benecchi et al. (2011)	1
2000 CE_{105}	Benecchi et al. (2011)	2
2000 CF_{105}	Tegler et al. (2003)	
	Benecchi et al. (2011)	
	Benecchi et al. (2009)	6
2000 CF_{105+B}	Benecchi et al. (2009)	1
2000 CG_{105}	Benecchi et al. (2011)	
	Snodgrass et al. (2010)	3
2000 CK_{105}	Benecchi et al. (2011)	2
2000 CL_{104}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	
	Peixinho et al. (2004)	4
2000 CN_{105}	Peixinho et al. (2004)	
	Jewitt et al. (2007)	4
2000 CO_{105}	Benecchi et al. (2011)	2
2000 CP_{104}	Benecchi et al. (2011)	2
2000 CQ_{105}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	
	Tegler et al. (2003)	
	Jewitt et al. (2007)	5
2000 CQ_{114}	Benecchi et al. (2011)	
	Benecchi et al. (2009)	3
2000 CQ_{114+B}	Benecchi et al. (2009)	1
2000 FS_{53}	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	2
2000 FV_{53}	Peixinho et al. (2004)	1
2000 FZ_{53}	Peixinho et al. (2004)	2
2000 GV_{146}	Benecchi et al. (2011)	1
2000 KK_{4}	McBride et al. (2003)	
	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	3
2000 KL_{4}	Benecchi et al. (2011)	1
2000 OU_{69}	Peixinho et al. (2004)	
	Benecchi et al. (2011)	3
2000 PD_{30}	Benecchi et al. (2011)	2
2000 PE_{30}	Delsanti et al. (2006)	
	Doressoundiram et al. (2007)	
	Benecchi et al. (2011)	
	Sheppard (2010)	
	Doressoundiram et al. (2001)	7
2000 PH_{30}	Benecchi et al. (2011)	1
2000 QL_{251}	Benecchi et al. (2009)	1
2000 QL_{251+B}	Benecchi et al. (2009)	1
2001 FL_{185}	Benecchi et al. (2009)	1
2001 FM_{194}	Tegler et al. (2003)	1
2001 FU_{172}	Snodgrass et al. (2010)	1
2001 KA_{77}	Doressoundiram et al. (2002)	
	Peixinho et al. (2004)	
	Doressoundiram et al. (2005b)	4
2001 KB_{77}	Peixinho et al. (2004)	6
2001 KD_{77}	Doressoundiram et al. (2002)	
	Peixinho et al. (2004)	
	Doressoundiram et al. (2007)	
	Benecchi et al. (2011)	9
2001 KG_{77}	Tegler et al. (2003)	1
2001 KY_{76}	Benecchi et al. (2011)	1
2001 OG_{109}	Benecchi et al. (2011)	1
2001 OK_{108}	Benecchi et al. (2011)	1
2001 QC_{298}	Benecchi et al. (2011)	
	Jewitt et al. (2007)	
	Benecchi et al. (2009)	3
2001 QC_{298+B}	Benecchi et al. (2009)	1

Table A.2. Continued

Object	References	Nr.
2001 QD_{298}	Doressoundiram et al. (2005b)	1
2001 QF_{298}	Doressoundiram et al. (2007)	
	Fornasier et al. (2004)	
	Delsanti et al. (2006)	
	Doressoundiram et al. (2005b)	8
2001 QX_{322}	Tegler et al. (2003)	
	Benecchi et al. (2011)	
	Jewitt et al. (2007)	3
2001 XR_{254}	Benecchi et al. (2009)	1
2001 XR_{254+B}	Benecchi et al. (2009)	1
2001 XU_{254}	Benecchi et al. (2011)	1
2001 XZ_{255}	Tegler et al. (2003)	1
2002 CB_{249}	Peixinho et al. (2004)	1
2002 DH_{5}	Peixinho et al. (2004)	1
2002 GB_{32}	Sheppard (2010)	1
2002 PP_{149}	Jewitt et al. (2007)	1
2003 FZ_{129}	Sheppard (2010)	1
2003 GH_{55}	Jewitt et al. (2007)	1
2003 HB_{57}	Sheppard (2010)	1
2003 HX_{56}	Snodgrass et al. (2010)	1
2003 QA_{92}	Romanishin et al. (2010)	1
2003 QD_{112}	Jewitt (2009b)	1
2003 QK_{91}	Sheppard (2010)	1
2003 QQ_{91}	Romanishin et al. (2010)	1
2003 QW_{111}	Benecchi et al. (2009)	1
2003 QW_{111+B}	Benecchi et al. (2009)	1
2003 QW_{90}	DeMeo et al. (2009)	2
2003 QY_{90}	Benecchi et al. (2009)	1
2003 QY_{90+B}	Benecchi et al. (2009)	1
2003 SQ_{317}	Snodgrass et al. (2010)	1
2003 TH_{58}	Snodgrass et al. (2010)	1
2003 TJ_{58}	Benecchi et al. (2009)	1
2003 TJ_{58+B}	Benecchi et al. (2009)	1
2003 UY_{291}	Sheppard (2010)	1
2003 UZ_{117}	Jewitt et al. (2007)	
	DeMeo et al. (2009)	4
2003 YL_{179}	Romanishin et al. (2010)	1
2004 OJ_{14}	Sheppard (2010)	1
2004 PB_{108}	Benecchi et al. (2009)	1
2004 PB_{108+B}	Benecchi et al. (2009)	1
2004 PT_{107}	Snodgrass et al. (2010)	1
2004 PY_{42}	Jewitt (2009b)	1
2004 VN_{112}	Sheppard (2010)	1
2004 XR_{190}	Sheppard (2010)	1
2005 CB_{79}	Snodgrass et al. (2010)	1
2005 EO_{297}	Sheppard (2010)	1
2005 EO_{304}	Benecchi et al. (2009)	1
2005 EO_{304+B}	Benecchi et al. (2009)	1
2005 GE_{187}	Snodgrass et al. (2010)	1
2005 PU_{21}	Sheppard (2010)	1
2005 SD_{278}	Sheppard (2010)	1
2006 SQ_{372}	Sheppard (2010)	1
2007 TG_{422}	Sheppard (2010)	1
2007 VJ_{305}	Sheppard (2010)	1
2008 KV_{42}	Sheppard (2010)	1
2008 OG_{19}	Sheppard (2010)	1
2008 YB_{3}	Sheppard (2010)	1
2060-Chiron	Hartmann et al. (1981)	
	Davies et al. (1998)	
	Parker et al. (1997)	
	Jewitt (2002b)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2007)	
	Green et al. (1997)	34
2223-Sarpedon	Fornasier (2007)	1
2357-Phereclos	Fornasier (2007)	1
3548-Eurybates	Fornasier (2007)	1
4035-1986 WD	Fornasier (2007)	2
4829-Sergestus	Fornasier (2007)	1

Table A.2. Continued

Object	References	Nr.
5130-Ilioneus	Fornasier (2007)	1
5145-Pholus	Binzel (1992)	
	Mueller et al. (1992)	
	Davies et al. (1993)	
	Davies et al. (1998)	
	Romanishin and Tegler (1999)	
	Weintraub et al. (1997)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2007)	
	Buie and Bus (1992)	
	Davies (2000)	
	Fink et al. (1992)	
	Green et al. (1997)	
	Tegler and Romanishin (1998)	41
5244-Amphilochos	Fornasier (2007)	1
5258-1989 AU_1	Fornasier (2007)	1
5511-Cloanthus	Fornasier (2007)	1
6545-1986 TR_6	Fornasier (2007)	1
6998-Tithonus	Fornasier (2007)	1
7066-Nessus	Davies et al. (1998)	
	Romanishin and Tegler (1999)	
	Bauer et al. (2003)	
	Davies (2000)	
	Tegler and Romanishin (1998)	17
7352-1994 CO	Fornasier (2007)	1
8405-Asbolus	Weintraub et al. (1997)	
	Brown and Luu (1997)	
	Davies et al. (1998)	
	Bauer et al. (2003)	
	Romon-Martin et al. (2002)	
	Davies (2000)	
	Rabinowitz et al. (2007)	
	Tegler and Romanishin (1998)	43
9030-1989 UX_5	Fornasier (2007)	1
9430-Erichthonio	Fornasier (2007)	1
9818-Eurymachos	Fornasier (2007)	1
10199-Chariklo	Davies et al. (1998)	
	Jewitt and Kalas (1998)	
	Romanishin and Tegler (1999)	
	N. McBride and Foster (1999)	
	Jewitt and Luu (2001)	
	Peixinho et al. (2001)	
	Bauer et al. (2003)	
	DeMeo et al. (2009)	
	Davies (2000)	
	Tegler and Romanishin (1998)	64
10370-Hylonome	Davies et al. (1998)	
	Romanishin and Tegler (1999)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2002)	
	Delsanti et al. (2006)	
	Davies (2000)	
	Tegler and Romanishin (1998)	25
11089-1994 CS_8	Fornasier (2007)	1
11351-1997 TS_{25}	Fornasier (2007)	1
11488-1988 RM_{11}	Fornasier (2007)	2
11663-1997 GO_{24}	Fornasier (2007)	1
12917-1998 TG_{16}	Fornasier (2007)	
	Dotto (2005)	2
12921-1998 WZ_5	Fornasier (2007)	2
13463-Antiphos	Fornasier (2007)	
	Dotto (2005)	2
13862-1999 XT_{160}	Fornasier (2007)	1
14707-2000 CC_{20}	Fornasier (2007)	2
15094-1999 WB_2	Fornasier (2007)	
	Dotto (2005)	3
15502-1999 NV_{27}	Fornasier (2007)	3
15535-2000 AT_{177}	Fornasier (2007)	
	Dotto (2005)	4

Table A.2. Continued

Object	References	Nr.
15760-1992 QB_1	Jewitt and Luu (2001)	
	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2001)	
	Benecchi et al. (2011)	
	Romanishin et al. (1997)	5
15788-1993 SB	Gil-Hutton and Licandro (2001)	
	Jewitt and Luu (2001)	
	Tegler and Romanishin (2000)	
	McBride et al. (2003)	
	Delsanti et al. (2001)	
	Benecchi et al. (2011)	6
15789-1993 SC	Davies et al. (1997)	
	Romanishin and Tegler (1999)	
	Jewitt and Luu (1998)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Benecchi et al. (2011)	
	Luu and Jewitt (1996)	
	Romanishin et al. (1997)	
	Tegler and Romanishin (1998)	17
15807-1994 GV_9	Gil-Hutton and Licandro (2001)	1
15809-1994 JS	Benecchi et al. (2011)	2
15810-1994 JR_1	Green et al. (1997)	
	Romanishin and Tegler (1999)	
	Benecchi et al. (2011)	
	Barucci et al. (1999)	
	Tegler and Romanishin (1998)	9
15820-1994 TB	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Delsanti et al. (2001)	
	Delsanti et al. (2004)	
	Delsanti et al. (2006)	
	Doressoundiram et al. (2007)	
	Barucci et al. (1999)	
	Davies (2000)	
	Romanishin et al. (1997)	
	Tegler and Romanishin (1998)	15
15836-1995 DA_2	Green et al. (1997)	
	Benecchi et al. (2011)	6
15874-1996 TL_{66}	Jewitt et al. (2007)	
	Jewitt and Luu (1998)	
	Romanishin and Tegler (1999)	
	Boehnhardt et al. (2001)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2007)	
	Barucci et al. (1999)	
	Davies (2000)	
	Tegler and Romanishin (1998)	16
15875-1996 TP_{66}	Jewitt and Luu (1998)	
	Romanishin and Tegler (1999)	
	Boehnhardt et al. (2001)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Barucci et al. (1999)	7
15883-1997 CR_{29}	Jewitt and Luu (2001)	
	Doressoundiram et al. (2001)	
	Benecchi et al. (2011)	3
15977-1998 MA_{11}	Fornasier (2007)	1
16684-1994 JQ_1	Green et al. (1997)	
	Gil-Hutton and Licandro (2001)	
	Boehnhardt et al. (2002)	
	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	8
17416-1988 RR_{10}	Fornasier (2007)	1
18060-1999 XJ_{156}	Fornasier (2007)	1

Table A.2. Continued

Object	References	Nr.
18137-2000 OU_{30}	Fornasier (2007)	1
18268-Dardanos	Fornasier (2007)	1
18493-Demoleon	Fornasier (2007)	2
18940-2000 QV_{49}	Fornasier (2007)	1
19255-1994 VK_8	Tegler and Romanishin (2000)	
	Doressoundiram et al. (2001)	
	Benecchi et al. (2011)	4
19299-1996 SZ_4	Jewitt and Luu (2001)	
	Tegler and Romanishin (2000)	
	McBride et al. (2003)	
	Boehnhardt et al. (2002)	5
19308-1996 TO_{66}	Jewitt et al. (2007)	
	Jewitt and Luu (1998)	
	Romanishin and Tegler (1999)	
	Hainaut et al. (2000)	
	Gil-Hutton and Licandro (2001)	
	Davies et al. (2000)	
	Jewitt and Luu (2001)	
	Boehnhardt et al. (2001)	
	Sheppard (2010)	
	Barucci et al. (1999)	
	Davies (2000)	
	Tegler and Romanishin (1998)	16
19521-Chaos	Davies et al. (2000)	
	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2001)	
	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2007)	
	Barucci et al. (2000)	13
20000-Varuna	Doressoundiram et al. (2002)	
	Hainaut (2001)	
	Jewitt and Sheppard (2002)	
	McBride et al. (2003)	
	Doressoundiram et al. (2007)	
	Jewitt et al. (2007)	
	Rabinowitz et al. (2007)	8
20108-1995 QZ_9	Gil-Hutton and Licandro (2001)	
	Tegler and Romanishin (2000)	
	Benecchi et al. (2011)	3
20161-1996 TR_{66}	Benecchi et al. (2011)	1
20738-1999 XG_{191}	Fornasier (2007)	
	Dotto (2005)	2
23549-Epicles	Fornasier (2007)	1
23694-1997 KZ_3	Fornasier (2007)	1
24233-1999 XD_{94}	Fornasier (2007)	1
24341-2000 AJ_{87}	Fornasier (2007)	1
24380-2000 AA_{160}	Fornasier (2007)	1
24390-2000 AD_{177}	Fornasier (2007)	
	Dotto (2005)	2
24420-2000 BU_{22}	Fornasier (2007)	1
24426-2000 CR_{12}	Fornasier (2007)	1
24444-2000 OP_{32}	Fornasier (2007)	1
24452-2000 QU_{167}	Fornasier (2007)	1
24467-2000 SS_{165}	Fornasier (2007)	1
24835-1995 SM_{55}	Gil-Hutton and Licandro (2001)	
	Boehnhardt et al. (2001)	
	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Jewitt et al. (2007)	
	Doressoundiram et al. (2007)	
	Rabinowitz et al. (2008)	10

Table A.2. Continued

Object	References	Nr.
24952-1997 QJ_4	Gil-Hutton and Licandro (2001)	
	Jewitt and Luu (2001)	
	Delsanti et al. (2001)	
	Boehnhardt et al. (2002)	4
24978-1998 HJ_{151}	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	2
25347-1999 RQ_{116}	Fornasier (2007)	1
26181-1996 GQ_{21}	McBride et al. (2003)	
	Boehnhardt et al. (2002)	
	Delsanti et al. (2006)	
	Doressoundiram et al. (2003)	
	Doressoundiram et al. (2007)	8
26308-1998 SM_{165}	Tegler and Romanishin (2000)	
	McBride et al. (2003)	
	Delsanti et al. (2004)	
	Doressoundiram et al. (2007)	
	Jewitt et al. (2007)	
	Benecchi et al. (2009)	8
26308-1998 SM_{165+B}	Benecchi et al. (2009)	1
26375-1999 DE_9	Jewitt and Luu (2001)	
	Delsanti et al. (2001)	
	Doressoundiram et al. (2002)	
	McBride et al. (2003)	
	Delsanti et al. (2006)	
	Doressoundiram et al. (2003)	
	Tegler et al. (2003)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	13
28958-2001 CQ_{42}	Fornasier (2007)	1
28978-Ixion	Doressoundiram et al. (2002)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	8
29981-1999 TD_{10}	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Doressoundiram et al. (2002)	
	Doressoundiram et al. (2007)	
	Consolmagno et al. (2000)	
	Rabinowitz et al. (2007)	18
30698-Hippokoon	Fornasier (2007)	3
31820-1999 RT_{186}	Fornasier (2007)	1
31821-1999 RK_{225}	Fornasier (2007)	1
31824-Elatus	Peixinho et al. (2001)	
	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Doressoundiram et al. (2007)	
	Gutiérrez et al. (2001)	14
32430-2000 RQ_{83}	Fornasier (2007)	1
32532-Thereus	Farnham and Davies (2003)	
	Tegler et al. (2003)	
	Barucci et al. (2002)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	221
32615-2001 QU_{277}	Fornasier (2007)	1
32794-1989 UE_5	Fornasier (2007)	1
32929-1995 QY_9	Gil-Hutton and Licandro (2001)	
	Davies et al. (2000)	
	Barucci et al. (1999)	5
33001-1997 CU_{29}	Tegler and Romanishin (2000)	
	Jewitt and Luu (2001)	
	Doressoundiram et al. (2001)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	6

Table A.2. Continued

Object	References	Nr.
33128-1998 BU_{48}	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Delsanti et al. (2006)	
	Bauer et al. (2003)	9
33340-1998 VG_{44}	Boehnhardt et al. (2001)	
	Doressoundiram et al. (2001)	
	McBride et al. (2003)	
	Doressoundiram et al. (2002)	
	Delsanti et al. (2006)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2007)	12
34785-2001 RG_{87}	Fornasier (2007)	1
35671-1998 SN_{165}	Jewitt and Luu (2001)	
	Gil-Hutton and Licandro (2001)	
	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Fornasier et al. (2004)	
	Doressoundiram et al. (2001)	6
38083-Rhadamanth	Boehnhardt et al. (2002)	1
38084-1999 HB_{12}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	
	Doressoundiram et al. (2001)	3
38628-Huya	Ferrin et al. (2001)	
	Jewitt and Luu (2001)	
	Schaefer and Rabinowitz (2002)	
	Boehnhardt et al. (2002)	
	McBride et al. (2003)	
	Doressoundiram et al. (2007)	
	Doressoundiram et al. (2001)	
	Rabinowitz et al. (2007)	58
39285-2001 BP_{75}	Fornasier (2007)	1
40314-1999 KR_{16}	Jewitt and Luu (2001)	
	Delsanti et al. (2006)	
	Boehnhardt et al. (2002)	
	Jewitt et al. (2007)	5
42301-2001 UR_{163}	Doressoundiram et al. (2007)	
	Doressoundiram et al. (2005b)	
	Benecchi et al. (2011)	6
42355-Typhon	Peixinho et al. (2004)	
	Tegler et al. (2003)	
	Doressoundiram et al. (2007)	
	Jewitt et al. (2007)	
	DeMeo et al. (2009)	
	Benecchi et al. (2009)	
	Rabinowitz et al. (2007)	12
42355-Typhon+B	Benecchi et al. (2009)	1
43212-2000 AL_{113}	Fornasier (2007)	1
44594-1999 OX_3	Tegler and Romanishin (2000)	
	Bauer et al. (2003)	
	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Boehnhardt et al. (2002)	
	Doressoundiram et al. (2002)	
	Peixinho et al. (2004)	
	Doressoundiram et al. (2005b)	
	Doressoundiram et al. (2007)	
	Delsanti et al. (2006)	
	Jewitt et al. (2007)	
	Sheppard (2010)	
	Doressoundiram et al. (2001)	30
45802-2000 PV_{29}	Benecchi et al. (2011)	2

Table A.2. Continued

Object	References	Nr.
47171-1999 TC_{36}	Boehnhardt et al. (2001)	
	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Delsanti et al. (2004)	
	Dotto et al. (2003)	
	Tegler et al. (2003)	
	Doressoundiram et al. (2007)	
	Protopapa et al. (2009)	
	DeMeo et al. (2009)	
	Benecchi et al. (2009)	
	Doressoundiram et al. (2001)	
	Rabinowitz et al. (2007)	23
47171-1999 TC_{36+B}	Benecchi et al. (2009)	1
47932-2000 GN_{171}	McBride et al. (2003)	
	Boehnhardt et al. (2002)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	13
47967-2000 SL_{298}	Fornasier (2007)	1
48249-2001 SY_{345}	Fornasier (2007)	1
48252-2001 TL_{212}	Fornasier (2007)	1
48639-1995 TL_{8}	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Sheppard (2010)	4
49036-Pelion	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2002)	
	Doressoundiram et al. (2002)	3
50000-Quaoar	Fornasier et al. (2004)	
	Tegler et al. (2003)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	4
51359-2000 SC_{17}	Fornasier (2007)	1
52747-1998 HM_{151}	Tegler and Romanishin (2003)	1
52872-Okyrhoe	Bauer et al. (2003)	
	Delsanti et al. (2001)	
	Dotto et al. (2003)	
	Delsanti et al. (2006)	
	Doressoundiram et al. (2007)	
	Doressoundiram et al. (2001)	18
52975-Cyllarus	Boehnhardt et al. (2001)	
	Delsanti et al. (2004)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2002)	
	Tegler et al. (2003)	9
53469-2000 AX_{8}	Fornasier (2007)	1
54520-2000 PJ_{30}	Benecchi et al. (2011)	1
54598-Bienor	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Tegler et al. (2003)	
	Dotto et al. (2003)	
	Bauer et al. (2003)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	15
55565-2002 AW_{197}	Doressoundiram et al. (2005a)	
	Fornasier et al. (2004)	
	Jewitt et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	9
55576-Amycus	Peixinho et al. (2004)	
	Bauer et al. (2003)	
	Fornasier et al. (2004)	
	Doressoundiram et al. (2005a)	
	Doressoundiram et al. (2007)	19
55636-2002 TX_{300}	Tegler et al. (2003)	
	Doressoundiram et al. (2005b)	
	Jewitt et al. (2007)	
	Ortiz et al. (2004)	
	Rabinowitz et al. (2008)	
	Rabinowitz et al. (2007)	8

Table A.2. Continued

Object	References	Nr.
55637-2002 UX_{25}	Jewitt et al. (2007)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	8
55638-2002 VE_{95}	Rabinowitz et al. (2007)	
	Barucci et al. (2006)	2
56968-2000 SA_{92}	Fornasier (2007)	1
58534-Logos	Jewitt and Luu (2001)	
	Boehnhardt et al. (2001)	
	Gil-Hutton and Licandro (2001)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	
	Benecchi et al. (2009)	7
58534-Logos+B	Benecchi et al. (2009)	1
59358-1999 CL_{158}	Doressoundiram et al. (2002)	1
60454-2000 CH_{105}	Peixinho et al. (2004)	
	Benecchi et al. (2011)	2
60458-2000 CM_{114}	Tegler et al. (2003)	
	Benecchi et al. (2009)	2
60458-2000 CM_{114+B}	Benecchi et al. (2009)	1
60558-Echeclus	Boehnhardt et al. (2002)	
	Delsanti et al. (2006)	
	Bauer et al. (2003)	
	Jewitt (2009b)	
	DeMeo et al. (2009)	8
60608-2000 EE_{173}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	
	Tegler et al. (2003)	3
60620-2000 FD_8	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	
	Peixinho et al. (2004)	3
60621-2000 FE_8	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Tegler et al. (2003)	3
63252-2001 BL_{41}	Bauer et al. (2003)	
	Doressoundiram et al. (2003)	
	Peixinho et al. (2004)	
	Tegler et al. (2003)	10
65150-2002 CA_{126}	Fornasier (2007)	1
65225-2002 EK_{44}	Fornasier (2007)	1
65489-Ceto	Tegler et al. (2003)	
	Jewitt et al. (2007)	
	Benecchi et al. (2009)	3
65489-Ceto+B	Benecchi et al. (2009)	1
66452-1999 OF_4	Peixinho et al. (2004)	
	Benecchi et al. (2011)	3
66652-Borasisi	Delsanti et al. (2001)	
	McBride et al. (2003)	
	Delsanti et al. (2006)	
	Benecchi et al. (2011)	
	Benecchi et al. (2009)	
	Doressoundiram et al. (2001)	7
66652-Borasisi+B	Benecchi et al. (2009)	1
69986-1998 WW_{24}	Doressoundiram et al. (2002)	
	Peixinho et al. (2004)	3
69987-1998 WA_{25}	Benecchi et al. (2011)	1
69988-1998 WA_{31}	Benecchi et al. (2011)	
	Peixinho et al. (2004)	2
69990-1998 WU_{31}	Peixinho et al. (2004)	1
73480-2002 PN_{34}	Tegler et al. (2003)	
	Doressoundiram et al. (2007)	
	Rabinowitz et al. (2007)	10
76804-2000 QE	Fornasier (2007)	1

Table A.2. Continued

Object	References	Nr.
79360-1997 CS_{29}	Romanishin and Tegler (1999)	
	Jewitt and Luu (2001)	
	Davies et al. (2000)	
	Boehnhardt et al. (2001)	
	Delsanti et al. (2006)	
	Benecchi et al. (2011)	
	Jewitt et al. (2007)	
	Barucci et al. (2000)	
	Benecchi et al. (2009)	
	Tegler and Romanishin (1998)	15
79360-1997 CS_{29+B}	Benecchi et al. (2009)	1
79978-1999 CC_{158}	Delsanti et al. (2001)	
	Doressoundiram et al. (2002)	2
79983-1999 DF_{9}	Doressoundiram et al. (2002)	1
80806-2000 CM_{105}	Benecchi et al. (2011)	
	Benecchi et al. (2009)	2
82075-2000 YW_{134}	Peixinho et al. (2004)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2005b)	
	Doressoundiram et al. (2007)	
	Jewitt et al. (2007)	
	Sheppard (2010)	
	Benecchi et al. (2009)	14
82155-2001 FZ_{173}	Peixinho et al. (2004)	
	Tegler et al. (2003)	
	Doressoundiram et al. (2007)	
	Jewitt et al. (2007)	9
82158-2001 FP_{185}	Peixinho et al. (2004)	
	Doressoundiram et al. (2005b)	
	Tegler et al. (2003)	
	Jewitt et al. (2007)	7
83982-Crantor	Peixinho et al. (2004)	
	Bauer et al. (2003)	
	Tegler et al. (2003)	
	Doressoundiram et al. (2005a)	
	Fornasier et al. (2004)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	17
84522-2002 TC_{302}	Sheppard (2010)	
	Rabinowitz et al. (2008)	2
84709-2002 VW_{120}	Fornasier (2007)	1
85627-1998 HP_{151}	Benecchi et al. (2011)	1
85633-1998 KR_{65}	Boehnhardt et al. (2002)	
	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	4
86047-1999 OY_{3}	Tegler and Romanishin (2000)	
	Boehnhardt et al. (2002)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Jewitt et al. (2007)	5
86177-1999 RY_{215}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2001)	3
87269-2000 OO_{67}	Tegler et al. (2003)	
	Benecchi et al. (2011)	
	Sheppard (2010)	3
87555-2000 QB_{243}	Peixinho et al. (2004)	
	Doressoundiram et al. (2007)	6
88269-2001 KF_{77}	Tegler et al. (2003)	1
88611-Teharonhia	Benecchi et al. (2009)	1
88611-Teharonhia+B	Benecchi et al. (2009)	1
90377-Sedna	Barucci et al. (2005)	
	Sheppard (2010)	
	Rabinowitz et al. (2007)	3
90482-Orcus	Rabinowitz et al. (2004)	
	de Bergh et al. (2005)	
	Rabinowitz et al. (2007)	6
90568-2004 GV_{9}	DeMeo et al. (2009)	
	Rabinowitz et al. (2008)	2

Table A.2. Continued

Object	References	Nr.
91133-1998 HK_{151}	Boehnhardt et al. (2001)	
	McBride et al. (2003)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Doressoundiram et al. (2001)	6
91205-1998 US_{43}	Peixinho et al. (2004)	2
91554-1999 RZ_{215}	Boehnhardt et al. (2002)	1
95626-2002 GZ_{32}	Doressoundiram et al. (2005b)	
	Bauer et al. (2003)	
	Tegler et al. (2003)	
	Fornasier et al. (2004)	
	Doressoundiram et al. (2007)	
	Rabinowitz et al. (2007)	18
99328-2001 UY_{123}	Fornasier (2007)	1
105685-2000 SC_{51}	Fornasier (2007)	1
111113-2001 VK_{85}	Fornasier (2007)	1
118228-1996 TQ_{66}	Romanishin and Tegler (1999)	
	Davies et al. (2000)	
	Gil-Hutton and Licandro (2001)	
	Jewitt and Luu (2001)	
	Benecchi et al. (2011)	
	Tegler and Romanishin (1998)	7
118379-1999 HC_{12}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	3
118702-2000 OM_{67}	Sheppard (2010)	1
119068-2001 KC_{77}	Tegler et al. (2003)	1
119070-2001 KP_{77}	Benecchi et al. (2011)	1
119315-2001 SQ_{73}	Tegler et al. (2003)	1
119951-2002 KX_{14}	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	
	Romanishin et al. (2010)	3
119979-2002 WC_{19}	Benecchi et al. (2009)	1
120061-2003 CO_{1}	Tegler et al. (2003)	
	Doressoundiram et al. (2007)	11
120132-2003 FY_{128}	DeMeo et al. (2009)	
	Sheppard (2010)	3
120178-2003 OP_{32}	Rabinowitz et al. (2008)	1
120347-Salacia	Benecchi et al. (2009)	1
120347-Salacia+B	Benecchi et al. (2009)	1
120348-2004 TY_{364}	Rabinowitz et al. (2007)	1
120453-1988 RE_{12}	Fornasier (2007)	1
121725-1999 XX_{143}	Bauer et al. (2003)	
	Doressoundiram et al. (2002)	
	Peixinho et al. (2004)	10
123509-2000 WK_{183}	Benecchi et al. (2009)	1
123509-2000 WK_{183+B}	Benecchi et al. (2009)	1
124729-2001 SB_{173}	Fornasier (2007)	1
127546-2002 XU_{93}	Sheppard (2010)	1
129772-1999 HR_{11}	Doressoundiram et al. (2001)	1
130391-2000 JG_{81}	Benecchi et al. (2011)	1
131695-2001 XS_{254}	Benecchi et al. (2011)	1
134340-Pluto	Buratti et al. (2003)	
	Jewitt and Luu (2001)	
	Buie et al. (2006)	4
134340-Pluto+B	Buie et al. (2006)	1
134340-Pluto+C	Buie et al. (2006)	1
134340-Pluto+D	Buie et al. (2006)	1
134860-2000 OJ_{67}	Doressoundiram et al. (2002)	
	Delsanti et al. (2006)	
	Benecchi et al. (2011)	
	Benecchi et al. (2009)	5
134860-2000 OJ_{67+B}	Benecchi et al. (2009)	1
135182-2001 QT_{322}	Romanishin et al. (2010)	1
136108-Haumea	Jewitt et al. (2007)	
	Rabinowitz et al. (2007)	
	Trujillo et al. (2007)	3
136199-Eris	Carraro et al. (2006)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2007)	64

Table A.2. Continued

Object	References	Nr.
136472-Makemake	Rabinowitz et al. (2007)	1
137294-1999 RE_{215}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	3
137295-1999 RB_{216}	Boehnhardt et al. (2002)	1
138537-2000 OK_{67}	Delsanti et al. (2001)	
	Delsanti et al. (2004)	
	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	5
144897-2004 UX_{10}	Romanishin et al. (2010)	1
145451-2005 RM_{43}	DeMeo et al. (2009)	
	Rabinowitz et al. (2008)	2
145452-2005 RN_{43}	DeMeo et al. (2009)	2
145453-2005 RR_{43}	DeMeo et al. (2009)	
	Rabinowitz et al. (2008)	3
145480-2005 TB_{190}	Sheppard (2010)	1
148209-2000 CR_{105}	Tegler et al. (2003)	
	Benecchi et al. (2011)	
	Sheppard (2010)	3
148780-Altjira	Benecchi et al. (2009)	1
148780-Altjira+B	Benecchi et al. (2009)	1
150642-2001 CZ_{31}	Delsanti et al. (2006)	1
163135-2002 CT_{22}	Fornasier (2007)	1
163216-2002 EN_{68}	Fornasier (2007)	1
168700-2000 GE_{147}	Benecchi et al. (2011)	1
168703-2000 GP_{183}	Doressoundiram et al. (2002)	
	Benecchi et al. (2011)	
	Peixinho et al. (2004)	5
181708-1993 FW	Green et al. (1997)	
	Tegler and Romanishin (2003)	
	Benecchi et al. (2011)	
	Barucci et al. (2000)	
	Romanishin et al. (1997)	8
181855-1998 WT_{31}	Peixinho et al. (2004)	
	Snodgrass et al. (2010)	3
181867-1999 CV_{118}	Peixinho et al. (2004)	1
181871-1999 CO_{153}	Benecchi et al. (2011)	1
181874-1999 HW_{11}	Benecchi et al. (2011)	
	Sheppard (2010)	2
181902-1999 RD_{215}	Boehnhardt et al. (2002)	
	Benecchi et al. (2011)	2
182397-2001 QW_{297}	Sheppard (2010)	1
182933-2002 GZ_{31}	Benecchi et al. (2009)	1
192388-1996 RD_{29}	Fornasier (2007)	1
192929-2000 AT_{44}	Fornasier (2007)	1
208996-2003 AZ_{84}	Fornasier et al. (2004)	
	Doressoundiram et al. (2007)	
	DeMeo et al. (2009)	
	Rabinowitz et al. (2008)	9