population, we drew a histogram as described above for our results too: the number of objects in the sample is too small to easily analyse the observed variability from a statistical point of view; nonetheless, there is no apparent trend of the NLS1s towards weak or absent variability characteristics; on the contrary, the objects for which we clearly detected a flux variation appear to distribute in the histogram in a similar way with respect to the comparison sample, e.g. they can reach relative variations around 30–40%. In Figure 2 we plot the two histograms described above, which show no evidence for a weak variability in the NLS1 sample, especially when only the flux variations above 3σ are considered.

While the absence of variability, or a significantly lower variability with respect to 'normal' Seyfert 1's, would have had strong implications on the interpretation of the NLS1s' spectrum, excluding that a smaller central mass or projection effects could be responsible for the narrower lines, the presence of variability on a time scale of one year does not entirely exclude the possibility (among the four listed in § 1.1) that we are actually observing broad line emitting gas located at relatively high distance from the centre (which represents the whole or only the outer part of the BLR); this gas could in fact be insensitive to variations on short-time scales, but responsive to long-term trends similar to the ones easily recognisable in the Hβ light curves of the de Ruiter and Lub data-set. To discriminate between the competing models it would be necessary to monitor a variable NLS1 (e.g. NGC 4051) with quite short time scales (days or weeks), such that the presence of variability would surely imply that the line-emitting gas is located very close to the centre (as in 'normal' BLRs), and therefore that a small black-hole mass or projection effects are to be responsible for the low FWHM observed. In a relatively long monitoring, moreover, it would be possible to measure the lag between the line and continuum light curves to have a better estimate of the BLR size, and compare it to that of other Seyferts.

At this stage we can set, for the size of the observed BLR in NLS1s, an approximate upper limit of the order of the light-year, since we would not observe any significant variations if the line-emitting gas would be located tens or hundreds of parsecs from the centre (as happens in the NLR). The observed BLR could represent therefore the outer part of a 'normal-sized' but partially obscured BLR, or the entire BLR in a type of object in which for some reason there is no line-emitting gas in the inner parsec region.

We can notice, however, that the annual relative variations measured in our comparison sample appear to belong to a long-term trend approximately in 30% of the cases (estimated by taking the events in which at least 4 points in the light curve show the same variation sign); therefore, a common variability in NLS1 galaxies, as that displayed by our data (~ 75% of objects varied in luminosity between the two epochs), is more probably consistent with models in which a BLR with 'canonical' size produces smaller observed velocities of the line-emitting gas, either for projection effects or for intrinsic reasons. We therefore tend to favour these types of explanation, that should be theoretically modelled to be able to compare in detail our predictions with the observed line profiles.

The fact that variability is detected in so many NLS1s is in any case a strong indication that these objects are not radically different, in size and nature, from normal Seyfert 1 galaxies.

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The DUO Programme:

First Results of a Microlensing Investigation of the Galactic Disk and Bulge Conducted with the ESO Schmidt Telescope

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Summary

We present the first results of a search for microlensing amplifications towards the Galactic centre region, aimed at investigating the populations of the disk and bulge in a wide field.

For this purpose, we used a first set of Schmidt plates taken on La Silla from April to September, 1994, digitised with the MAMA microdensitometer, and analysed with a software specially developed for highly crowded fields.

Some ten microlensing candidates, including what appears to be an amplification by a double lens, could be present in the data produced by the reduction of half of the field. Thousands of variable stars are also evidenced by this survey.

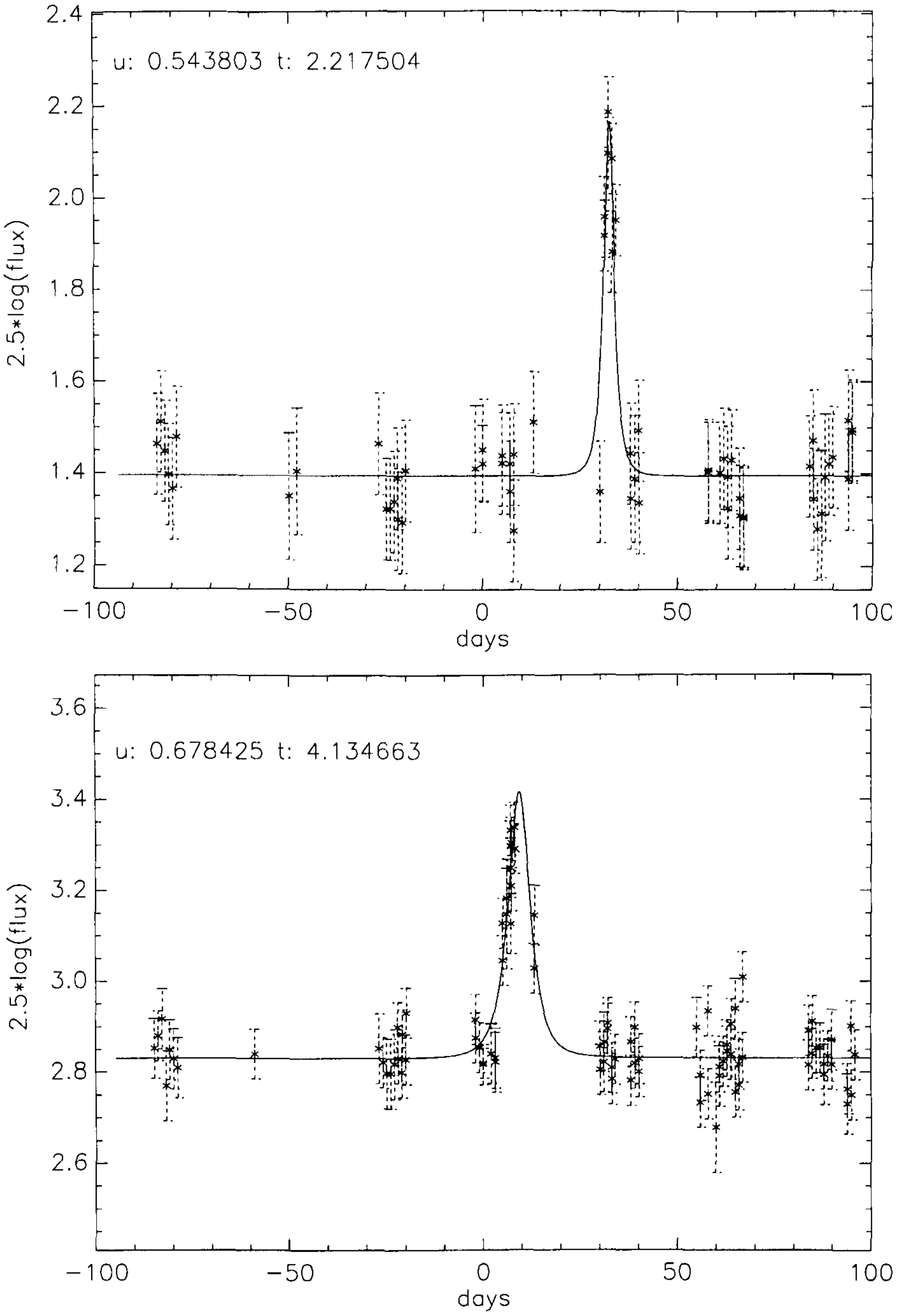

Figure 1: Two examples of microlensing candidates so far extracted from the data. Data from blue plates. The amplifications are close to 0.8 and 0.6 mag. respectively. At rest, star #a (top) is fainter than star #b (bottom) by about 1.4 mag, hence the larger error bars. For significance of the parameters, see Paczynski (1991): t the time it takes the relative positions of the source and lensing star to change by the apparent Einstein radius Re; u is the impact parameter (R/Re).

This wealth of information will contribute, together with the results obtained by the OGLE and MACHO groups, to improve our knowledge of the stellar populations and galactic structure in this region.

1. The DUO Project and its Objectives

The French DUO ("Disk Unseen Objects") project (Alard, 1995a, Alard et al., 1995) takes advantage of the large field of the ESO Schmidt telescope to investigate the stellar populations between the Sun and the Galactic centre. The area of one photographic plate (30 square degrees) covers a wide range of galactic coordinates, in the case of the DUO field : from *b*II = –4 to *b*II = –10, and from *ℓ*II = 0 to *ℓ*II = +6.

In this respect, DUO is complementary of the MACHO and OGLE CCD projects, which can benefit, among others, from a denser time sampling, but over a more restricted area.

In the region surveyed here, the stellar density is particularly large, but the extinction is moderate and relatively homogeneous, allowing monitoring of about 12 million objects on each Schmidt plate.

As was done for the EROS project (Aubourg et al., 1993), digitisation of the photographic material is performed with the fast and accurate microdensitometer MAMA (Machine Automatique à Mesurer pour l'Astronomie), designed and operated by INSU (Institut National des Sciences de l'Univers/CNRS), and located at Observatoire de Paris.

The scientific objectives of this project include:

– detection of low luminosity (if not dark) objects through microlensing amplification.

The EROS and MACHO groups reported the detection of microlensing candidates towards the Large Magellanic Cloud (Alcock et al., 1993, Aubourg et al., 1993), in the course of investigations aiming at searching for baryonic dark matter in the Galactic halo.

Towards the region of the Galactic centre, microlensed as well as microlensing objects can *a priori* be located either in the bulge, or in the disk. It is worth noting that our knowledge of the faint end of the stellar luminosity function is presently rather poor, even in the solar vicinity.

The OGLE and MACHO groups have already reported the detection of candidates in this direction using CCD detectors (see, for instance, Szymanski et al., 1994 and references therein, Alcock et *al.*, 1995a). The unique feature of the DUO programme is its wide field which will allow us to produce a large-scale map of the microlensing optical depth. This is particularly important in order to disentangle the contributions of lenses situated in the disk and in the bulge, since their spatial distributions are very different (see, for example, the theoretical maps calculated by Evans, 1994 and Kiraga, 1994)

– structure of the bulge, and particularly of the Bar, the characteristics of which still remain largely unknown at the present time.

– study of stellar populations in general, using the multi-colour photometry which will be available for a large number of stars.

– short-period variables.

– long-period variables.

Several types of short- as well as long-period variables are interesting distance indicators. As a consequence, extensive monitoring of a large number of objects is expected to significantly improve our knowledge of the 3-D distribution of stellar populations in the bulge, particularly if the extinction can be estimated from visible and/or infrared multiband photometry.

Similar "by-products" of microlensing experiments are being obtained in the EROS, MACHO, and OGLE projects

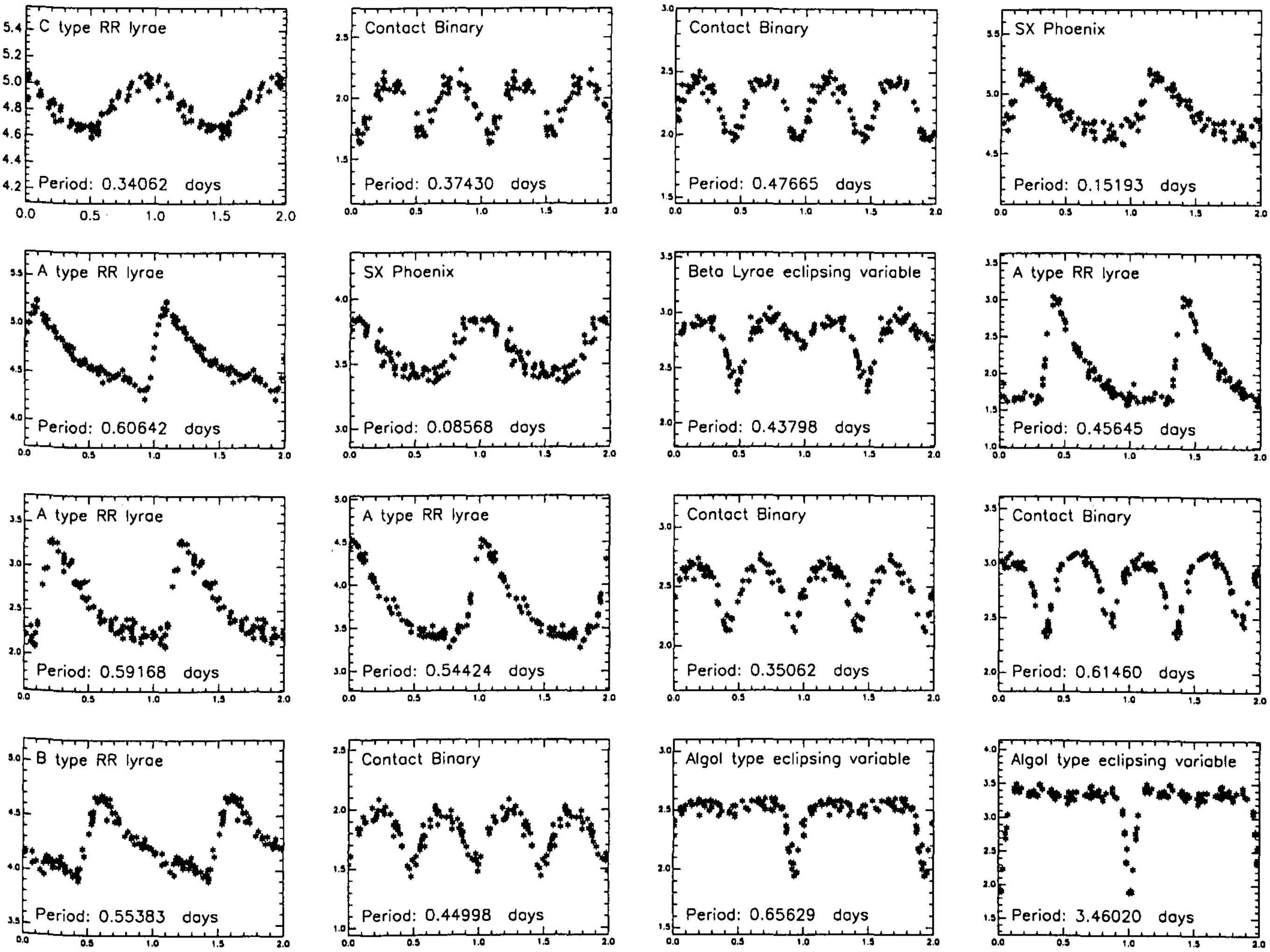

Figure 2: Some examples of the 10,000–15,000 new short-period variables expected from the DUO project. The variability type, derived from the shape and characteristics of the light curve, is indicated at the top of each box. The phase appears in abscissa, and the amplitude (in mag.) in ordinate. The light curve is repeated once for clarity.

(e.g.: Udalski et al., 1994a, Grison et al., 1995, Beaulieu et al.,1995).

2. Observations and Scanning

The plate material for the 1994 campaign is composed of about 200 plates, mainly IIIaJ and IIIaF, taken with the classical GG385 and RG630 filters, respectively, thus giving access to the blue and red parts of the spectrum. A few plates have also been obtained in other bands, namely with the combinations IIIaJ/UG1, IIIaF/GG495, IVN/RG715, for more detailed characterisation of the stars.

The plates were taken over a six-month period around June 1994, most often two IIIaJ and one IIIaF plates per dark night, all three with 20 minutes exposure.

The limiting magnitude is close to 21 and 19 in the blue and red colours, respectively. In view of the time sampling obtained in the blue band, microlensing events of short durations as well as short-period variables, known to be numerous in this region, are within the reach of the project.

The digitisation of one ESO Schmidt plate, performed with a 10 μm (0.67 arcsec) step, yields a series of FITS images requiring a total storage space of 1.6 Gbyte.

3. Reduction and Preliminary Results

In the DUO field, the stellar density, as detectable on Schmidt plates, turns out to range from 200 (in the north-west corner), to 100 (south-east corner) stars per square millimetre – i.e. per square arcmin. As a result, a total number of about 12 million stars can be monitored.

A special software has been designed and developed by one of us (Alard, 1995b) for optimal detection and photometry of this huge number of objects in a rather crowded field. The resolution achieved is better than 0.1 mag. for most of the monitored stars, and often better than 0.05 mag. For the magnitude calibration, CCD frames have been obtained at La Silla with the ESO/Danish 1.54-m telescope.

At the time of writing (April, 1995), half of the field has been entirely reduced, resulting in 8 million light curves. For each star, the stored information comprises the coordinates of the object on the reference plate, and, for the other plates, three bytes describing the magnitude and a confidence indicator. Therefore, for this zone, the requested storage space is 6 Gbytes.

From this significant amount of data, a first set of microlensing candidates, among them an object with a light curve suggesting a binary lens, has already been detected.

A high number of periodic variable objects has also been discovered, essentially eclipsing binaries and RR-Lyrae stars of various types. A total number of 10,000–15,000 such objects is expected for the whole DUO field. Long-period variables, for instance Miras, and irregular red variables, are also numerous in the region.

These first results are hereafter presented in some detail.

4. Microlensing Candidates

The theoretical microlensing magnitude variation has been fitted to the observed light curves after a preselection made among the time series, on the basis of consecutive three-σ deviations with respect to the minimum. The achromatism of the amplifications can be checked only for stars which, when not amplified, are sufficiently above the limiting magnitude of the red plates. The resolution is also better for the IIIaJ plates.

From the reduction of the first half of the field so far performed, some ten events appear to be reliable candidates for microlensing amplifications. Two examples, chosen among these, are shown in Figure 1.

Among the candidates, an object with an unusual light curve has been detected with three consecutive peaks within 7 days. This behaviour is quite surprising for an intrinsically variable object, and the most likely explanation seems to be an amplification by a double lens (Alard et al., 1995). The possibility of observing microlensing by multiple lens, anticipated by Mao and Paczynski (1991), has already been put forward by the OGLE group (Udalski et al., 1994b) on candidate OGLE #7, and later confirmed independently by the MACHO collaboration (Alcock et al., 1995b).

The confirmation of the suspected candidates, with characteristic durations ranging from 3 to more than 60 days, will require scanning and reducing the whole stack of plates, including those taken in the U band, in particular to eliminate the possibility that these events are produced by dwarf novae (Della Valle 1994).

5. Variable Stars

Figure 2 displays a set of short-period variables which are representative of the variety of the new interesting objects detected in the DUO field.

Eclipsing binaries represent the dominant population among the variable stars discovered in the course of our survey. The most numerous are contact binaries with periods smaller than one day, followed by Algol-type objects and Beta-Lyr systems, this ranking being consistent with the results obtained by the OGLE group (Udalski et al., 1994a) on 116 eclipsing binaries discovered in the centre of the Baade's Window. The large number of eclipsing objects which will be produced by the DUO survey is expected to make possible statistical investigations of this population which has been only poorly studied up to the present time.

RR-Lyrae stars represent about 20% of the variable objects so far detected in the DUO field. These can be used to map the interstellar reddening, and are also good distance indicators. They are therefore invaluable in investigations of the structure of the Galactic bulge. The latter issue is of prime importance, in particular, for the study of the Bar. Although the existence of the Bar appears to be well established by now, its orientation and axis ratio are still poorly known.

This component of the galactic structure is receiving special attention from the groups involved in microlensing projects (see, e.g. Kiraga, 1994 and references therein, Stanek, 1995 , Zhao et al., 1995, and references therein). The optical depth to gravitational microlensing in the direction of the Galactic bulge appears to be in excess by a factor of 5–10 with respect to the previously expected values (see, e.g. Evans 1994 and references therein). This could be due to bulge-bulge gravitational amplifications, the Bar playing a major role in this process if oriented towards the Sun as proposed by several authors.

6. The Near Future

The reduction of the second half of the field is in progress. Additional observations will be necessary, especially to improve the time base line, as well as to increase the statistics of microlensing events, and for the study of the long-period variables. This is the reason why we have applied for a second run at the ESO Schmidt: IIIa plates and Kodak 4415 Tech Pan films will be taken on La Silla from May to August 1995.

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The Variation of Atmospheric Extinction at La Silla

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1. Introduction

A total of 248,000 stellar photometric measurements have been obtained from the Swiss station at La Silla from July 1977 to August 1994, during about 4400 nights of photometric quality. These seven-colour photometric measurements in the Geneva System (Golay, 1980; Rufener, 1988) have been obtained by using successively two telescopes (40 cm and 70 cm), two photo-electric photometers and one CCD camera, from two different locations on the site of La Silla.

A very homogeneous set of photometric data, and, in consequence, of data on Earth atmospheric extinction in the optical domain has been collected. A first analysis of the atmospheric extinction variations was published by Rufener (1986, hereafter Paper I) for the period from November 1975 to March 1985. The annual and long-term variations were described as well as the effect of the