structure. The time of the fall was determined as 3500 ± 1300 years before present by means of Carbon-14 dating by A.J.T. Jull of the University of Arizona, Tucson, U.S.A. This technique is based on the fact that while the meteorite is still in space, it is continuously bombarded by cosmic rays, leading to a particular internal proportion of Carbon-12 and -14 atoms. As soon as it passes through the Earth's atmosphere, it is shielded from cosmic rays and the proportion begins to change as the radioactive Carbon-14 atoms decay. A measurement of this proportion will therefore indicate the time since the fall.

Some of the minor planets, along with the comets, are thought to consist of material that dates back to the very beginning of the solar system. The minor planet from which the Vaca Muerta meteorite derives is about 4500 million years old and therefore nearly as old as the solar system itself.

The early life of this minor planet was obviously very violent. At some time a partially molten, volcanically active body moving at high speed through the solar system collided catastrophically with a metallic-core minor planet. When the finely intertwined materials cooled and solidified, they formed a cosmic breccia (mixture of minerals) which was half stony and half metallic. Later, after an unknown period of time, this minor planet split into a swarm of smaller fragments, some of which now fall to the Earth at rare moments. One of them was the Vaca Muerta meteorite.

This particular kind of stony-iron meteorite is known from about 30 other locations only. The amount recovered at Vaca Muerta has tripled the material available to laboratory study. When fully analysed, the seventy-seven "dead cows" from Atacama will undoubtedly provide us with much new insight into the enigmatic history of the early solar system.

GPO Observations of a Geostationary TV-Satellite Quartet

H. BOEHNHARDT, Dr.-Remeis-Sternwarte, Bamberg, Germany

1. Introduction

During an astrometry campaign on asteroids a test was performed to observe geostationary satellites with the GPO 40-cm astrograph at ESO La Silla/Chile. In several nights from April 10 to 22, 1991, spacecraft located at geostationary longitude 19 deg West about 35800 km above the equator were photographed with the GPO. At this longitude in total four telecommunication satellites are operated by three different control centres, i.e. TDF-1 and TDF-2 by CNES Toulouse, OLYMPUS by Telespazio Fucino under contract of ESA and TV-SAT-2 by GSOC/DLR Oberpfaffenhofen.

In order to guarantee the contact with the fixed mounted user antennas on ground, the individual spacecraft have to be kept in control boxes of certain latitude and longitude intervals. The respective control boxes are in inclination below 0.1 deg for all four satellites, in longitude within 18.7 to 18.9 deg West for both TDF satellites, within 18.9 to 19.1 deg West for OLYMPUS and within 19.1 to 19.3 deg West for TV-SAT-2. A violation of these so-called deadbands by one of the satellites may not only cause problems for the users on Earth because of fading signal strength, but may also be a risk for the spacecraft themselves in particular if the longitude window of a neighbouring satellite is entered and a collision of both satellites may occur. Since perturbations from the Earth, the Moon and the Sun cause a geostationary satellite to drift away from its nominal position, the control centres have to correct the orbit regularly both in inclination and in longitude by so-called "station-keeping manoeuvres".

2. The GPO Observations

The geostationary longitude 19 deg West over the Earth equator compares to the telescope coordinates of +4.6 deg in declination and hour angle 3h 52.8 min East for the La Silla observatory. During the about 30-minute time interval of dark-room work per night (in order to change plates for the asteroid programme) old ORWO ZU21 plates found in the refrigerator of the telescope building were exposed with the tele-

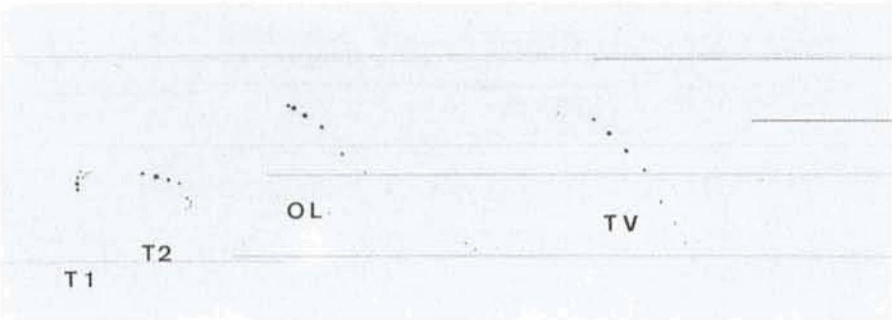

Figure 1: *Multi-exposure of the geostationary quartet at Longitude 19 deg West obtained on April 22, 1991. In total 11 five-minute exposures were taken starting every full hour from 0 UT onwards in order to demonstrate the daily libration of the spacecraft. North is up and East is to the left. The image scale is 0.70 × 0.26 deg. The satellites moved from East towards West during the observing night. T1 = TDF-1; T2 = TDF-2; OL = OLYMPUS; TV = TVSAT-2.*

scope pointing to the geostationary satellites. The telescope tracking was switched off during these satellite exposures. Therefore, on the plates the stars appear as dark lines across the field of view, while the geostationary objects are black dots or short trails (see Figs. 1 and 2; the poor quality of the images is due to the rather old plate material used).

Since the satellite orbits have an inclination usually different from zero and the orbital eccentricity is not exactly zero, the geostationary spacecraft perform a daily libration which is a superposition of a latitudinal, a longitudinal and a radial motion similar to 3-dimensional Lissajous figures. A part of the daily libration of the four satellites is visualized in Figure 1 in projection onto the celestial sphere. This image obtained on April 22, 1991, contains in total 11 five-minute exposures with starting time each full hour. However, only the first nine exposures show the geostationary quartet on the plate. Unfortunately, the telescope moved slightly in declination for a yet unknown reason between exposure 4 and 5 which has introduced an artificial shift of the satellites' motion towards south. For a minimization of fuel consumption geostationary satellites like the 19 deg West quartet are usually operated with perigee pointing approximately towards the Sun. Therefore, the daily longitudinal and radial libration is synchronized, which can clearly be seen in Figure 1. All four spacecraft moved from East towards West during the observing interval.

This picture also illustrates the daily brightness variations of the three-axis stabilized satellites because of the temporal changes in the phase angle Sun-spacecraft-observer. All four satellites are brightest around 1 UT (second exposure), i.e. when the Sun is in "opposition" to the satellites. Furthermore, the

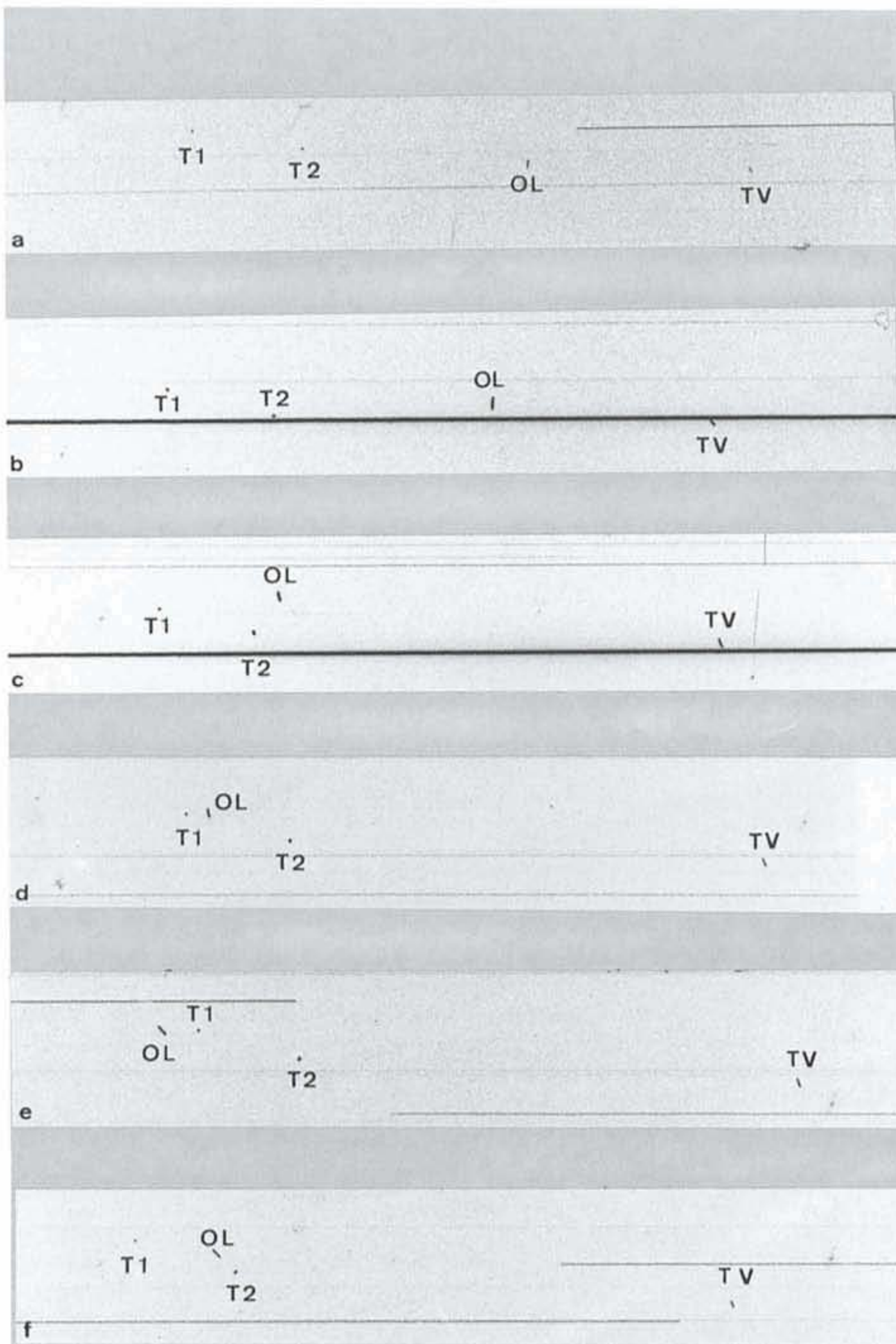

Figure 2: *Sequence of exposures of the geostationary quartet at longitude 19 deg West obtained between April 10 and 20, 1991.*
From April 17 to 20, 1991, a longitude deadband violation of OLYMPUS is documented. North is up, East is to the left. The image scale is 0.70 × 0.12 deg. Satellite abbreviations as in Figure 1.
a: April 10, 1991 06:19:30–06:39:20 UT.
b: April 11, 1991 05:16:00–05:38:00 UT.
c: April 17, 1991 04:43:00–05:03:00 UT.
d: April 18, 1991 05:08:30–05:29:10 UT.
e: April 19, 1991 05:12:00–05:32:32 UT.
f: April 20, 1991 05:40:20–05:59:20 UT.

exposures 10 and 11 obtained at 9 and 9.30 UT, respectively, did not depict the spacecraft at all, probably because most of the satellite surfaces seen from La Silla were in shadow.

3. The Deadband Violation of OLYMPUS

In the sequence of exposures obtained between April 17 and 20, 1991, a so-called longitude deadband violation of OLYMPUS was documented by chance (see Figs. 2a–f). It occurred because of altitude control problems due to onboard sensor errors. For comparison on April 10 and 11, 1991, all four spacecraft were positioned within their control boxes (see Figs. 2a, b). On April 17, 1991, OLYMPUS was already about to pass its eastern longitude limit (see Fig. 2c). It entered the neighbouring TDF control box and can be seen between TDF-1 and TDF-2 on April 18, 1991 (see Fig. 2d), and even east of both TDFs on April 19, 1991 (Fig. 2e). The following day it drifted back to its nominal control box (see Fig. 2f) where it was found inside again on April 22, 1991 (see Fig. 1). Fortunately, this "excursion" of OLYMPUS out of its control box has caused no hazard to the neighbouring TDFs. However, the control centres certainly try to avoid such contingencies during normal operations, in particular for colocated spacecraft like the quartet at 19 deg West.

The astrometric plates obtained on the geostationary satellites can be used to measure the angular distances between the spacecraft. These angles can be transformed into projected inter-satellite distances in kilometers with an accuracy of less than 1 km in geostationary orbit. This is at least of the order or even better than the accuracy of the proximity checks using radio tracking data. Therefore, the optical observations may be useful as an additional check for the orbital proximity calculations of colocated geostationary satellites.

4. Acknowledgement

I like to thank Mr. Rüdiger Knigge of the Dr.-Remeis Observatory, Bamberg, for providing me with the excellent photoprints of the original GPO plates.

Mini-Workshop on Large-Size CCDs at ESO

S. D'ODORICO, T. DUCROS, O. IWERT and R. REISS, ESO

Which is the maximum size of a high-quality scientific CCD detector that industry can now deliver? How can the UV-blue quantum efficiency of the devices be enhanced? What are the best design approaches and the limiting performance of CCD controllers? These questions are puzzling engineers and scientists who have to do with the definition, design and procurement of the detectors and their control systems for astronomical applications. Projects like the instruments for the ESO Very Large Telescope stress the need of devices of large size and state-of-the-art performance in order to take full advantage of the larger collecting area of the telescopes. To focus on these open questions and to obtain a snapshot of this fast developing field, ESO organized on June 18th and 19th in Garching a mini-workshop on "Large Size CCD". Invited were representatives from European groups with a proven experience in this field, a few experts from overseas and speakers of CCD manufacturers with an interest in the astronomy market. The workshop was organized in three sections dedicated to CCD Controllers, CCD Operation/Testing/Design and finally to Presentations from industry. The workshop programme (see box) gives titles and authors of the talks whereas the paragraphs below summarize status and highlights of the various topics, as seen through the (possibly) biased eyes of the authors.

In the field of CCD CONTROLLERS, a variety of systems have been developed at different observatories with the aim of optimizing those operating parameters which are of relevance for the astronomical applications.

The *analog section* of the controller is beside the intrinsic quality of the CCD the dominating part as for what concerns the final quality of the signal processing and the CCD scientific data. The intrinsic CCD read-out noise has been significantly improved in the last years due to the progress in the semiconductor technology and this develop-

PRESENTATIONS AT THE ESO CCD WORKSHOP

F. Bortoletto, Obs. of Padova: "Activity of the Italian CCD working group"

J. Bregman, Radiosterrewacht, Dwingeloo: "Performance of CCD controller systems built for the 4.2-m WHT at La Palma"

P. Müller, University of Bonn: "Flexible CCD Controller for BOCCIA"

C. Cara, CEA Saclay: "A high performance microsequencer based on logic cell arrays"

R. Reiss, ESO Garching: "Present and future CCD controllers at ESO"

A. Blecha, Obs. de Genève: "High level interactive control using the CCD with a small telescope"

K. Reif, University of Bonn: "BOCCIA: the Bonn CCD imaging and analysing project"

M. Roth, Munich University Obs.: "Photometric CCD test facility and telescope simulator"

P. Jorden, RGO, Cambridge: "The operation of large EEV CCDs on the WHT at La Palma"

J. Geary, Harward Smithsonian Obs.: "Custom design of CCDs for astronomy"

R. F. Nielsen, Copenhagen University Obs.: "CCD development at Copenhagen University Obs."

J. Geary, Harward Smithsonian Obs.: "Thinning of Large CCDs"

G. Weckler, EG & G, U.S.A.: "EG & G Reticon's commitment to scientific imagers – present and future status"

A. Jutant, Thomson, France: "TMS' CCD production and large CCDs"

U. Fiedler, Tektronix, Germany: "Status of the Tektronik TK 2048 imagers"

R. Bredthauer, LORAL, U.S.A.: "Large area astronomical imagers at LORAL"

P. J. Pool, EEV, U.K.: "Recent developments of CCDs at EEV"