Connections between CCD and GPO at La Silla

During the night of October 1, 1989, O.H. Hofmann and H. Rabhan found a fast-moving asteroid with a CCD from their home institute, mounted on the ESO 1-m telescope. It was recognized later as 4197 1982 TA, a very recently numbered asteroid.

The following nights, till October 12.0 (Moon = 0.88) and perhaps October 13.0 (Moon = 0.95), we observed this asteroid at the GPO (magnitude equal to 15.6).

M. Hoffmann writes about this collaboration: "Visual discoveries of asteroids by chance have become unusual in astronomical research during this century. New observing techniques, however, have led to a new variety of this "method". When CCD images of star fields are displayed in the control rooms of the telescopes, there is a finite probability that unexpected objects also appear on the screens. Unfortunately, a large fraction of this recorded information remains unnoticed and will be erased from the magtapes eventually.

We had an opportunity to combine the ESO 1-m telescope with a CCD-camera system of the DLR for a programme of photometry of near-Earth asteroids. These objects use to move quickly through considerable angles in the sky.

The night of October 30/31, 1989, we suddenly noticed that one of the background stars in a field of (4197) 1982 TA jumped 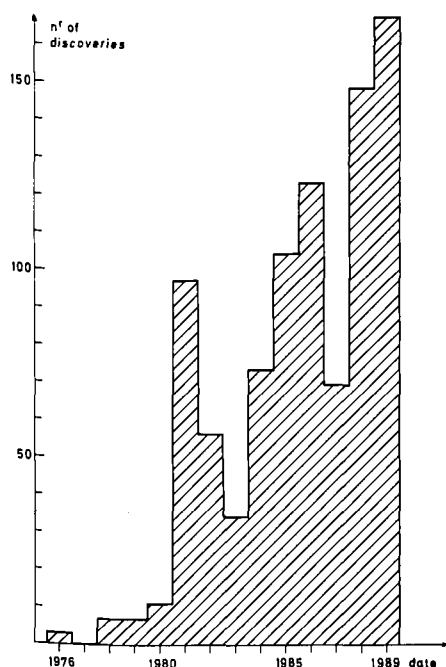a little westward from frame to frame. From its speed and direction of motion we concluded that it might be a normal main-belt asteroid close to opposition and estimated its position for the next night. It could then be recovered on exposures of the GPO and followed during the next days.

It is obvious that a CCD camera can lead to many similar discoveries when pairs of images are compared during the subsequent image processing."

Institutions Involved

The Observatorio do Valongo, Universidade Federal do Rio de Janeiro (UFRJ), the Observatories of Uppsala, Belgrade, Turin, Rio de Janeiro, the University of Teheran and the Royal Observatory of Belgium (Uccle-Bruxelles) have all taken part in the missions.

Theoretical Developments: New Ideas

Theorem of the minimum. In the reductions (more generally, in the rectangular algebraic systems), the error effect where the error is acting will be minimum at the gravity centre of the reference stars (of the independent terms) only for systems of odd degree (1, 3, 5, 7 . . .), not for even degree (Debehogne, 1972).

The *Einstein effect* must be solved by the simulation method (Debehogne, 1977). This is a work only for astrometrists skillful in asteroids.

In the orbital computations, the effect on the elements of *systematical errors* on the observations is a linear function of the error value and a sinusoidal one of the error direction: for each element we find two directions with an error effect equal to zero for whatever error value (Theorem of the two directions without error effect) (Debehogne, 1988).

The test stars are used to study the *external accuracy* (Debehogne, 1970). Fictitious reference stars and fictitious errors (Debehogne, 1972) are also used.

If it is necessary to use observational sequences from instruments with different focal lengths and to use uncatalogued stars, except on the instrument with the shorter one, then the final accuracy will be the accuracy of the measurements on the plate taken with the larger one, when the subsets of intermediate reference stars are sufficient: the number of stars for each instrument should be equal to 10 times the degree of the bijections used.

Conclusions

Editors, editorial boards and referees ought to support the publication of positions of known and also of new minor planets. The *Minor Planet Circulars* are important, but they are not accepted as publications by the "Money Authorities"?

Each position is the determination of a bijection between two sets of points (sky and plate) by means of two subsets (reference stars). That implicates the resolution of one or two rectangular, algebraic systems of equations (reduced to squared ones, by the matrix or by the least squares method). Such discoveries, such mathematical developments, such theorems, coming directly from the observations and having implications in mathematics, ought to be supported. The lack of publication possibilities is a pity; a new "Journal des Observateurs" would be highly desirable.

Acknowledgements

The photographical service (J. Peres, E. Araya, A. Torrecon, R. Tighe) on La Silla, by plate heating (Kodak IIa-O, 16 × 16 cm), has made it possible for us to obtain a gain of 1.5 magnitudes. ESO supports all missions for H. Debehogne and partly those for a colleague. J. Dumoulin and G. Peeters have participated.

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Figure 2: *Discoveries from 1976 to 1989. Discovery is taken in the sense that they are recognized as ours by the Minor Planet Center (MPC). Numbered: 62.*