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N91-24385

14680

p.3

Spacewatch Search for Near-Earth Asteroids

Tom Gehrels
Lunar and Planetary Laboratory
The University of Arizona

Abstract

The objective of the Spacewatch program is to develop new techniques for the discovery of near-Earth asteroids and to prove the efficiency of the techniques. We have obtained extensive experience with a dedicated facility, the 0.91-meter Spacewatch Telescope on Kitt Peak, that now has the largest CCD detector in the world, a Tektronix 2048 x 2048 with 27-micron pixel size. During the past year, Research Associate D. L. Rabinowitz joined us in order to help with the installation of software and hardware for optimizing the discovery of near-Earth asteroids. As a result, automatic detection of objects that move with rates between 0.1 and 4 degrees per day has come into routine operation beginning in September 1990.

We appear to be discovering one or two near-Earth asteroids per month, on average. The follow up is with astrometry over as long an arc as the geometry and faintness of the object allow, typically three months following the discovery observations.

During the second half of 1990 we began to consider to increase the discovery rate by replacing the 0.91-m mirror with a larger one. Studies and planning for this switch are proposed for funding during the coming year. We also propose to move the Spacewatch Telescope on the sky, instead of the present mode of having the drive turned off, in order to increase the rate of discoveries by perhaps a factor of 2.

The Work of this Year

Our main concern during the present year is with the software of the computer system that was newly installed at the Spacewatch Telescope. The Solbourne computer was delivered in October 1989 at about the same time that Dr. David Rabinowitz joined us to do the programming for it, together with J. V. Scotti who had programmed everything for us before. Now, however, the computer routines are much more advanced, with recognition of elongated images and of image motion for moving objects. The fastest of near-Earth asteroids make trails on the CCD frame; during our usual scanning with the drive off the exposure time is about 3 minutes, long enough for a sizeable trail. Rabinowitz had been trained by John Simpson and his group at the University of Chicago in image recognition; he also has an interest and training in physical studies of comets which will be useful in our future. The recognition of asteroid motion had been programmed by J. V. Scotti before and used for quite some time on our 320 x 512 RCA CCD, and now it was adapted and expanded for usage with the new 2048 x 2048 Tektronix CCD. Rabinowitz wrote a paper for the Astronomical Journal describing in detail the software routines for image and motion recognition.

The trail and motion recognition programs have been in operation with the 2048 x 2048 CCD system and the Solbourne computer at the Spacewatch Telescope on Kitt Peak since the middle of April. Since that time, refinements have been programmed on the Solbourne and they were tested night by night during the dark runs of May and June. Further expansion of memory was needed and this was put into operation.

The observing was completely suspended during the months of July and August because of major repair and maintenance to the telescope and also because the monsoon and the short summer nights make the observing less efficient; even in September we still had a lot of cloudy weather.

During the summer Gehrels went again to India where the program of building a 1.27-m Scannerscope has been officially approved for funding by the Indian Government and by the Smithsonian Institution. The first stone was laid for their dome at the Kavalur Observatory in Southern India. They already have a scanning system at their 2.3-m prime-focus reflector at Kavalur, using some of our software that had been made available beforehand during a visit of Indian colleagues to Arizona.

Our Spacewatch system on Kitt Peak began full operation in September of 1990. Its special strength is that it can detect objects when they are far away and slow moving, down to 0.05 deg/day, in addition to fast ones. The observer can decide at a glance whether the object is a Jovian Trojan (or even slower), at various distances in the a main belt, near the inside of the asteroid belt, just barely crossing the Mars orbit, or one that may come even closer to Earth. It is noted, however, that such discrimination works only when the observations are made near opposition, within a region in ecliptic latitude that is opposite the Sun, where the motion of the object is primarily a reflex of the orbital motion of the Earth.

Since the limiting magnitude of this system is about 20.5 (at 6-sigma detection), we find as many as 400 asteroids per night, which are mostly the ones in the main belt. Because they are so faint, they are nearly all new findings. We let them go, however, because it would take too much time away from discovery scanning to get the astrometric observations that are required for precise orbits. Only the ones that appear to be near-Earth asteroids are followed up with such astrometry in the following weeks and months.

Rabinowitz and Scotti had already in October 1989 discovered our first near-Earth asteroid, 1989 UP. It had been found through visual recognition of a trail on the Solbourne screen, and it was reported in Circular 4887 of the International Astronomical Union (IAU). Its perihelion distance is 0.98 AU, indicating that it is gravitationally controlled by the Earth and may eventually impact. Aphelion is in the middle of the asteroid belt where it probably originated. Its mean diameter is 0.3 km; that is in the lowest 10% of the sizes of near-Earth asteroids that are presently known. W. Wisniewski (personal communication, 1989) observed a lightcurve amplitude of more than a magnitude. It is therefore an elongated object, probably a fragment of a collision in the asteroid belt.

As noted before, automatic operation began in September 1990, which yielded a run with poor weather, but near-Earth asteroid 1990 SS was discovered, an Apollo. October 1990 had exquisite conditions, and four new ones were discovered. In addition, we rediscovered 1865 Cerberus, periodic comet Kopff and our own 1990 UP. The table lists our new objects. The diameters are based on a mean for carbonaceous and silicaceous reflectivity yielding a diameter of 0.075 km for 1990 UN (Bowell, personal communication, 1990). 1990 UN is the smallest natural object observed outside the Earth's atmosphere (IAU Circular 5130); this has drawn attention as far as Hiroshima, Japan! 1990 UP has a peculiar orbit, close to Mars' distance, and a period of rotation of about 16 hours (Wisniewski, personal communication, 1990), possibly slowed by multiple collisions from the usual 2-6 hours for these objects. Or, it may be an extinct cometary core, as it has a high inclination, and its rotation rate was then controlled by outgassing. We still have not learned how to distinguish such cores from fragments of collisions in the asteroid belt.

Discoveries of the Second Spacewatch Survey

Identification	Perihelion distance (AU)	Aphelion distance (AU)	Incli-nation (deg)	Dia-meter (km)	Date of discovery	Remarks
1989 UP	0.98	2.7	3.9	0.3	89.10.27	elongated
1990 SS	0.87	3.0	25.4	1.0	90.09.25	
1990 TG1	0.78	4.1	8.9	4.3	90.10.14	
1990 UN	0.81	2.6	3.7	0.08	90.10.22	small (H=23.8)
1990 UO	0.31	2.1	27.4	0.3	90.10.22	crosses the Mercury orbit
1990 UP	1.11	1.6	28.7	0.3	90.10.24	slow rotation
1990 VA	0.72	1.2	14.1	2.3	90.11.09	Aten

Perspectives for Next Year

By moving the telescope during the scans the area coverage can be increased so that fast-moving objects have shorter trails, whereby objects are discovered in larger numbers than before. We are beginning to try this, with new software, while the telescope drive also needs improvement. This points in the direction of replacing the 0.91-m mirror with a larger one. We can do this efficiently as a larger telescope, up to 2-m aperture, will fit inside our dome on Kitt Peak. This new plan was further stimulated by T. Triffet by his introduction of the Spacewatch programs to the University of Arizona Foundation for funding.

We propose to prepare more in detail the next configuration of our telescope with a larger mirror. Availability of mirrors, optical designs, CCD parameters, mirror support system and cost estimates will be studied in order to make the program more realistic and specific for fund raising by the University of Arizona Foundation. R. S. McMillan is expert in instrumentation and we are fortunate to have him with some time available for these conceptual designs. For more detailed calculations and drawings we consult with engineer M. Williams.

Steady progress is expected at Kavalur and at Kitt Peak both. With the Spacewatch Telescope we begin to move the telescope so as to increase the area coverage for fast-moving objects, as mentioned. Until now we have obtained the scans by turning off the drive, and the old 36-inch telescope cannot move very fast, but a factor of 2 in area coverage seems possible. We will be observing with the Spacewatch Telescope during all available dark time of about 17 nights per month which already includes about 3 nights more than the half of the month that we had originally negotiated with our partners who search for planets of other stars during the bright half of the month.

In conclusion, we thank the NASA Space Engineering Research Center and its officers for the stimulating support we are receiving.