SMALL BODIES OF THE SOLAR SYSTEM

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Schmidt telescopes are ideal for many types of survey work, and this includes surveying the solar system. Schmidt cameras have the advantages of speed and wide fields for rapid coverage of large areas of the sky, and good image quality over the entire field. The small focal ratios also have the effect of enhancing low surface-brightness features. This is an advantage for studying cometary tails and comae.

Current work in the field of small solar system objects can be divided into three different areas: searching for new objects, recovering lost objects, and astrometry of known objects. Each of these areas requires its own techniques.

Searches for new objects generally concentrate on fast-moving asteroids, slow-moving asteroids, and planetary satellites. Again, each type of object requires a different technique for discovery. Of course, comets are also often found with Schmidt telescopes, but they are usually found during the course of other work, rather than during deliberate searches.

1. FAST-MOVING OBJECTS

Fast-moving objects include the Apollo, Amor, and Aten asteroids. These objects pass relatively close to the Earth, and thus have rapid angular motion across the sky. Motions of a degree or more per day are typical. For these objects, the wide field and speed of Schmidt telescopes are especially valuable. It is estimated that approximately 1000 Apollo asteroids with diameters greater than one kilometer exist in the solar system. Only about 60 of these have been discovered thus far. These objects are important in the study of the cratering history of the inner planets.

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They may also be relevant to the study of comets, since it is suspected that some Apollo asteroids are "extinct" comets. Some of these asteroids are relatively easy to reach with space probes, and may become important sources of raw materials for manufacturing structures in space in the future.

Searches for fast-moving asteroids are being conducted by Eugene Shoemaker and Eleanor Helin, with the 0.46-meter Schmidt telescope at Palomar. These searches have resulted in the discovery of the first asteroid having a semi-major axis of less than 1 A.U., as well as some prime candidates for space missions.

Many Apollo-type asteroids have also been found in the course of other work, such as supernova searches, because these asteroids can appear anywhere in the sky, and are not concentrated toward the ecliptic.

Fast-moving objects are usually found by looking for relatively long trails on photographs. Shoemaker and Helin, however, use a stereoscopic technique in which two photographs of a region are examined simultaneously in a stereoscopic viewer. Any moving objects then appear to "stand out" from the stellar background. The two photographs are taken only about 30 minutes apart.

2. SLOW-MOVING OBJECTS

Slow-moving objects include all objects beyond the asteroid belt. These are the Trojan asteroids, and unusual objects like Chiron and Hidalgo. Trans-Plutonian planets could also be included in this category, as well as "Trojans" of the outer planets.

Searches for slow-moving objects usually require that two or more plates of a region be photographed one day apart. The plates are then examined under a blink microscope in order to find the moving objects. The photographs must be taken within 15 degrees of the opposition point (i.e. 180 degrees from the Sun). Near the opposition point, the apparent motion of an object is a function of its distance from the Earth and Sun. This allows us to discriminate between main-belt asteroids and the more distant objects. At greater distances from the opposition point, the main-belt asteroids move more slowly, and can mimic the motion of more remote objects.

A search for very distant objects has been conducted by Kowal, using the Palomar 1.2-meter telescope. About two-thirds of the ecliptic has been photographed during this survey, to a limiting magnitude of 20-21. As a result of this survey, the object 'Chiron' was discovered in 1977, near the orbit of Uranus. As by-products of the search, one Apollo asteroid and two comets were discovered. The asteroid Adonis and Comet Taylor, (1916 I), were also recovered, after having been lost for many decades. An expanded survey of this type, but using automated blinking techniques, would greatly increase our knowledge of the population of small bodies throughout the solar system. It is already clear that the solar system does not consist of only the known planets, comets, and a well-defined asteroid belt.

3. SATELLITES

Although planetary satellites are usually studied with long-focus instruments, the satellite systems of Jupiter and Saturn cover such a large angular extent that wide-angle Schmidt telescopes can be used to great advantage. This was demonstrated in 1974, when Kowal discovered J XIII (Leda). The entire satellite system of Jupiter spreads across five degrees of the sky.

Because of internal reflections and scattered light from these bright planets, it is necessary to block the planet's light with an opaque mask. Satellites close to the planet are covered by this mask, or buried in the scattered light, so only the outer satellites can be photographed.

4. OTHER WORK

Wide-field telescopes are of obvious benefit in the study of comet tails, which can be many degrees long. Since the features within these tails can change on a timescale of hours, it is advantageous to photograph a comet at several observatories around the world for continuous time coverage. Such a co-operative effort will be conducted during the International Halley Watch in 1985-86.

The recovery of lost asteroids and comets is another area in which Schmidt telescopes have been used very successfully. The original observations of lost objects are re-analyzed, and new orbits and ephemerides are computed. Then, one or more plates are taken of the area around the ephemeris position. In this way, many objects that had been missing for decades have been recovered with a moderate expenditure of telescope time, (but with a considerable expenditure of computer time)!

5. FUTURE WORK

The demise of astronomical photography is often predicted, but the future of Schmidt telecopes seems secure for the rest of this century. One photographic plate contains a vast amount of information, and great progress could be made by the use of automated retrieval of this information. Research on small bodies in the solar system could well be revolutionized by the use of automated plate scanning, position measurement, and "blinking" of photographic plates. The use of such devices is not yet widespread, because of the great expense involved.

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