Asteroids, Comets, Meteors 1991, pp. 455–458
Lunar and Planetary Institute, Houston, 1992

A NEW METHOD FOR ASTROMETRIC OBSERVATIONS OF ASTEROIDS

Thierry PAUWELS
Koninklijke Sterrenwacht van België, Ringlaan 3, B-1180 Brussel, Belgium

Abstract. In this paper we propose a new method for photographic astrometric observations of asteroids. We discuss its advantages and disadvantages and compare them to the advantages and disadvantages of the classical photographic methods. The new method is best suited for observations on a spot where no CCD cameras, blink or stereo comparators are available and when a fast detection of unknown objects is required.
Key words: asteroids – astrometry

1. INTRODUCTION

When no accurate positions are known, on astrographic plates asteroids reveal themselves among the stars by their motion only. Therefore astrographic observations of asteroids are always done in such a way that moving objects can easily be detected on plates. Nowadays, plate scanners or CCD cameras have made this detection easier. However, CCD's still have a small field and are not available everywhere. Plate scanners are often not available close to the observing site. So, in many cases observers still have to use the old photographic methods, and afterwards scan the plates with their eyes. Here, we propose a new photographic method and compare its advantages and disadvantages with those of the well-known classical photographic methods. Since the proposed method is of no use in CCD observations, we shall not compare it to CCD observations.

2. SIX METHODS

First method. One long exposure: moving objects show trails.

DISADVANTAGES

- Much sky background on plate.
- Very difficult and uncertain detection of objects, especially when the exposure time is not too long: double stars can look exactly like moving objects.
- No indication of the sense of the motion of moving objects.
- Large reference stars, difficult to measure.
- Elongated moving objects, difficult to measure.

ADVANTAGES

- Detection of moving objects is reasonably fast.
- Very good plates for archival purposes (historical record for possible later use in other astronomical applications).

Second method. Trépied-Metcalf exposure: guided on the expected (mean) motion of the target object(s). Objects with this motion show circular images. Objects with slightly different motions show slightly elongated images.

DISADVANTAGES

- Detection of moving objects is very difficult, and almost impossible when no position is known in advance. Therefore this method should be used in combination with another method.
- Elongated reference stars, difficult to measure.
- Bad for archival purposes.
- Not possible when different target objects have very different motions.
- Target objects can be wiped out by star trails.

ADVANTAGES

- Moving objects will give very good measurements.
- Ideal for very faint objects.

Third method. Gated exposure: several exposures on the same plate without any shift between the exposures. The interruptions must be long enough to give detached images for objects moving at the expected speed. Usually the gating is asymmetric in order to give the sense of the motion.

DISADVANTAGES

- Much sky background on plate.
- Large reference stars, difficult to measure.
- Loss of time during the interruption(s).
- Images of object can be elongated, difficult to measure.
- Several images of the objects to be measured for only one position.
- Problem with epoch determination of position, especially if the shortest exposure(s) give images too faint to be measured.

ADVANTAGES

- Very fast and secure detection of moving objects.
- The sense of the motion of moving objects can be derived, provided that the gating is asymmetric.
- Good plates for archival purposes.

Fourth method. Two plates. These are taken with a certain time interval, so that moving objects have different positions. Moving objects are detected by blinking the plates or by stereo comparison. This method can be combined with the Trépied-Metcalf technique.

DISADVANTAGES

- Detection of moving objects impossible without a stereo or (expensive) blink comparator.
- Very slow detection of moving objects.

ADVANTAGES

- Very secure detection of moving objects.
- The sense of the motion of moving objects can be derived.
- No loss of time between the two plates (except when target objects are very slow).
- Good plates for archival purposes.
- Two independent positions can be derived.
- Possible even for extremely slow objects.

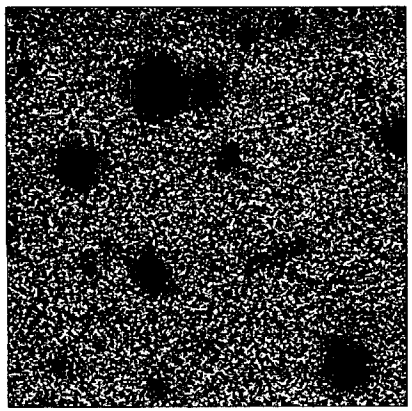
Fifth method. Several exposures on the same plate. Between the exposures there is a shift, so that all objects show several images. Moving objects, however, will show a different pattern. This method can be combined with the Trépied-Metcalf technique.

DISADVANTAGES

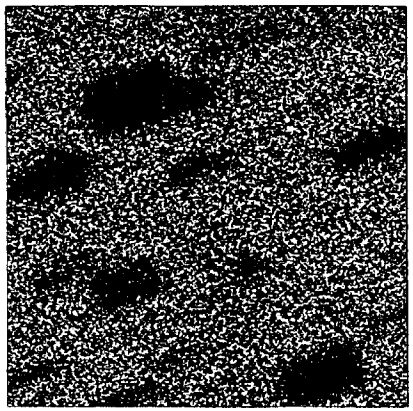
- Much sky background on plate.
- Very bad plates for archival purposes.
- Difficult detection of moving objects in crowded fields.

ADVANTAGES

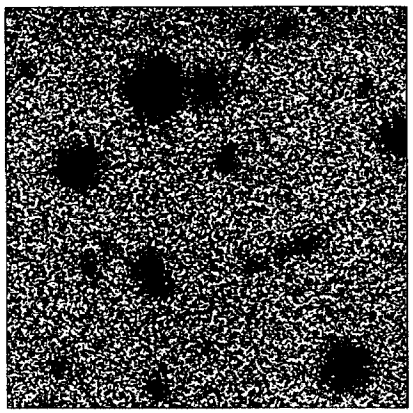
- Reasonably easy detection of moving objects in low-density fields.
- The sense of the motion can be derived.
- No loss of time between the exposures (except when target objects are very slow).
- Several independent positions can be derived.



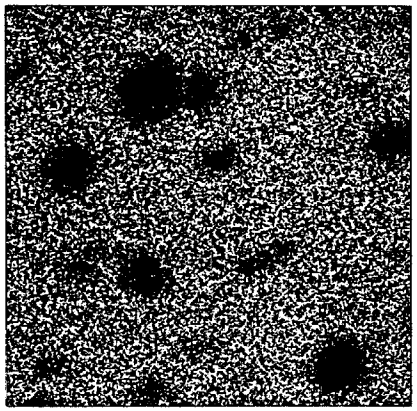
First method.



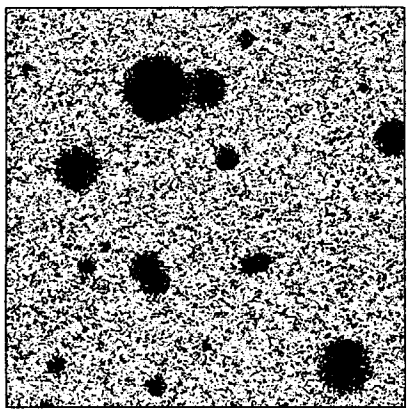
Second method.



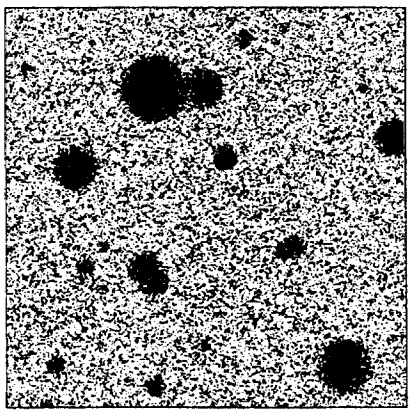
Third method.

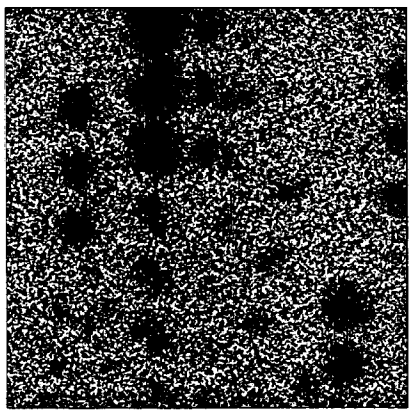


Proposed method.



Fourth method.





Fifth method.

Figure. How a fictitious star field with an asteroid looks like in the classical methods and the proposed method. For a good view, hold about one metre from you.

Proposed method. Several superimposed Trépied-Metcalf exposures. A first exposure is started with the telescope guiding at the average motion of the target objects. After some time, the telescope is brought back to the starting position, and a new exposure is started. This is done as many times as the number of exposures (and asteroid images) wanted, with all exposures of the same length. The duration of these exposures should correspond to a motion that is at least the diameter of the images of the target objects on the plate, in order to get detached images for the target objects. Stars will show only one (elongated) image, while moving objects will show several images. For objects with exactly the introduced motion, the images are circular; for objects with slightly different motions, the images will be slightly elongated.

DISADVANTAGES

- Much sky background on plate.
- Reference stars are somewhat elongated, and difficult to measure.
- Only moderately good plates for archival purposes.
- Several images of the moving objects to be measured for only one position.
- The minimal exposure times must be long enough to detach the different images of the moving objects.
- Not possible when different target objects have very different motions.
- Not possible when target objects are too slow.

ADVANTAGES

- Very fast and secure detection of moving objects.
- No loss of time between the exposures.
- High accuracy measurements thanks to several almost circular images of moving objects.
- Good for faint objects.
- The sense of the motion can be derived.

3. CONCLUSION

All methods described here have their own advantages and disadvantages. The specific conditions in which observations are done will determine which of the advantages and disadvantages are dominant, less important or irrelevant. On a very good location with a very dark sky or with an instrument with long focal length the quantity of sky background is less important. When observing well-known objects the detection speed is irrelevant. Large stars are difficult to measure in the classical way, but this is no longer the case when using a Schmidt telescope (giving sharp spikes around bright stars), or when digitizing the plates. Combining two methods can also remove some of their disadvantages.

The proposed method seems to be best suited for observing on a site where no CCD cameras are available, where no blink or stereo comparator is at hand and where a fast detection of unknown moving objects is required. The observer can also use the proposed method for the discovery of objects, and use one of the classical methods (or small field CCD observations) for the follow-up.

Acknowledgements. The author would like to thank Dr. E. Bowell for his useful comments and for bringing the last disadvantage of the second method to his attention.