EPSC Abstracts
Vol. 6, EPSC-DPS2011-1323, 2011
EPSC-DPS Joint Meeting 2011

CABERNET network cameras for high accuracy meteor orbits determination

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Abstract

Meteoroid steams are responsible of 30,000 metric tons of rocks falling on our planet every year, therefore they are with NEOs the main vector for mater mitigation within the solar system. The main way to study them is to observe their impact on Earth as meteor showers. But these observations mainly done with video camera suffer of a lack of accuracy, so it is impossible to have an accurate view of the streams in the past. We present here the first results of CABERNET camera using a large CCD chip for a good astrometry and a special acquisition mode which allow acquisition rate up to 1 Khz.

1. Introduction

To get accurate orbits we need large format CCD sensors for good astrometric measurements, in the same time as meteors are fast objects (20 degrees/sec) we also need fast acquisition rate which is a bit contradictory. Our first idea for fast acquisition rate like 100 hz for large CCDs was to use a rotating shutter like photographic observations [1], but it seems that it can be critical for the longevity of the camera and moreover for the measurements accuracy. We solved this problem by using a line transfer CCD in a special "meteor" mode.

1.1 CABERNET camera

The camera is based on the Lhéritier LH11000 device using a Kodak Kai 11002 chip (4032x2688 pixels), it is a line transfer CCD with a 7.5 hz full frame acquisition rate. This rate is quite impressive to read the 11 Mega pixel chip but really too slow for meteor observations. Line transfer CCD are not used for astronomy as they suffer from a lack of quantum efficiency, but they could be used in a special mode to simulate an electronic shutter.

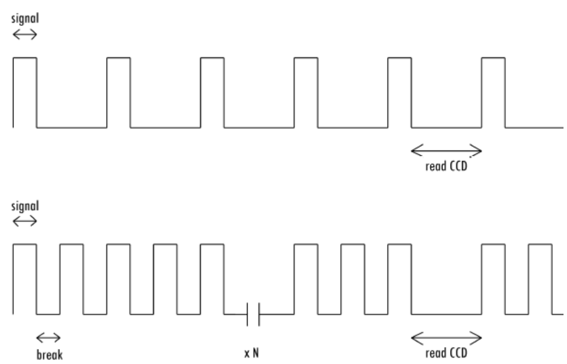

Figure 1 : modification of the line transfer CCD to mimic an electronic shutter

Figure 1 shows chronograms of the two modes to use an interline CCD. In the "normal" mode (top), after the exposition time (signal), the charges are transferred into to the memory lines where they are read and wiped. In the "meteor" mode (bottom), after the exposition time (signal) the charges are transferred to the memory lines without reading. Before starting a new acquisition, CCD sensitive lines are wiped, during this "break time" the CCD doesn't acquire photons, so it operates like a shutter. The CCD is read after few cycles, so we reduce the read out time. The shutter rate can be as fast as 1 Khz and is easy to adjust to a specific value for a meteor shower. For example for the 2010 Geminids, we used a 100hz shutter speed and a 100 cycle before reading the CCD (figure 2). The camera is mounted on a Canon 50mm F/1.2 lens, the field of view is 40 x 30 deg.

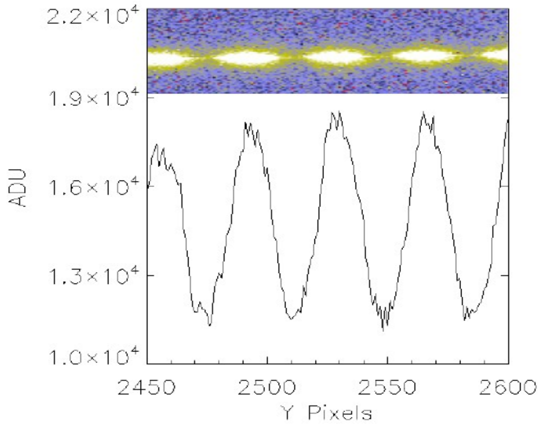

Figure 2 Top, example of a meteor with 20 ms signal, 20 ms break and total exposure of 1 seconds. Bottom, The intensity of meteor breaks along X axis.

1.2 CABERNET network

To get orbits with need to use a network of camera for parallax measurements. As meteors are located at an altitude of 100 km, observers used locations distant of 100km [1] in order to see the meteors with different geometry. Our first network is based in the south of France with Pic du Midi observatory and Guzet ski resort. The idea was to use to high altitude locations to have the same weather conditions, in a near future we will add a third location to optimize the observations.

Figure 3 CABERNET network

2. Geminids 2010 campaign

During the 12th and 13th December nights, we took for both stations 180000 images. We founded around 100 meteors observed by the two CABERNET systems. Data have been processed but we still need to develop tools to compute accurate orbits. This run was important to test the electronic shutter and the camera efficiency. Our configuration used 50 cycles of 40 ms, so one image every 2 seconds. The star detection limit was magnitude 8.5, for meteors we used video observations for photometric calibrations, we founded magnitude 3. Other tests have to be done to optimize the acquisition pipe line.

3. Summary and Conclusions

Our network is still at an early stage of development, but results are encouraging. The aim of our project is to be operational for at least 10 years to have not only an exhaustive view of the mater in the Earth vicinity but in the whole solar solar system using backward integration of accurate orbits

Acknowledgements

We thanks the Paris City Emergences Grant, the PNP (Programme National de Planetologie) and Paris Observatory (BQR) for funding our project. The also thanks Pic du Midi observatory and Guzet ski resort for their help to install our cameras.

References

[1] Ceplecha, Z., Borovička, J., Spurný, P: Dynamical behavior of meteoroids in the atmosphere derived from very precise photographic records, Astronomy and Astrophysics, v.357, p.1115-1122, 2000)