Searching for SL-9 Impact Light Echoes – a Challenge for High-Speed Multi-Channel Photometry

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Shortly after the announcement of probable impacts of Comet SL-9 on the far side of Jupiter, the idea was born to use suitable Jovian moons as mirrors in order to witness the very first impact phenomena which would otherwise not be directly visible from Earth. First estimates of the energies released in the optical during the entry of the comet fragments into Jupiter's atmosphere indicated possible flash-like illuminations of the inner Jovian satellites increasing their brightness for a moment by up to a few per cent. We therefore proposed high-speed multi-colour photometry of the Gallilean moons during the predicted impact times. The aim of this programme was to derive the actual impact times at Jupiter and to estimate the flash temperature as well as the energy released in the visual wavelength range. The knowledge of the exact impact times would establish reliable reference points for the proposed studies of the propagation of impact phenomena through the Jovian atmosphere and for seismic observations. Furthermore, accurate impact times could help to select and transmit to Earth the most interesting images obtained by the Galileo spacecraft from the far side of Jupiter.

Our multi-channel multi-colour photometer (MCCP), mounted on the ESO 1-m telescope was thought to be the most suitable instrumentation for a light-echo search. This special photometer allows three light sources in the focal plane of a telescope to be selected by using optical fibers. Each of them is connected to a prism spectrograph providing UBVRI signals to photon- counting detectors. Thus, simultaneous multicolour observations, e.g., of a variable programme star, of a nearby comparison and of the sky background can be performed with a maximum time resolution of 20 ms. In particular, these measurements allow to compensate for variable atmospheric extinction by applying the so-called standard reduction procedure which computes the intensity ratio of two star channels after individual sky subtraction.

A search for impact light echoes requires simultaneous monitoring of at least two Jovian satellites and of the sky background. Due to different radial distances to Jupiter only the moon nearest to the impact site is supposed to exhibit an observable flash reflection which, even under non-photometric conditions, should become visible after data reduction. Originally, the input fibers of the MCCP were fixed by means of acrylic masks which had to be prepared prior to observations. However, for our observing programme this method had to be replaced by computer-controlled positioning devices for each fiber since differential orbital motions of the Jovian satellites require continuous centring of the individual fibers. This difficult task could be completed after four months. The new device was then successfully tested at the Wendelstein observatory in the Bavarian Alps a few nights before shipping the MCCP to La Silla at the end of June.

During our first observing night at La Silla on July 15, all photometer components as well as the measuring procedures were checked again (Fig. 1). A CCD camera was used to guide the ESO 1-m telescope on the rim of the Jovian disk whereas two moons were monitored through diaphragms in front of the fiber-positioning devices. For their individual tracking motions, a programme provided by O. Montenbruck (DLR) was used to

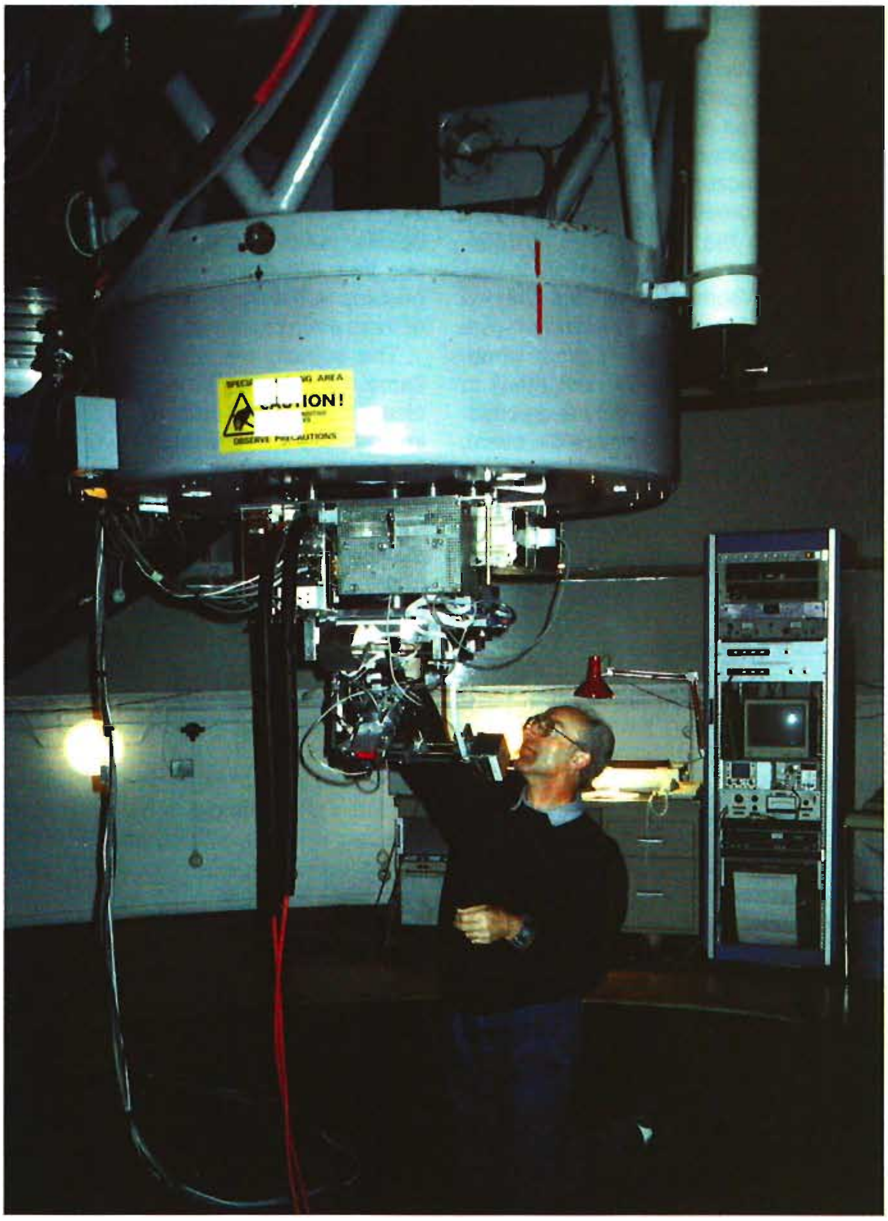

Figure 1: *The multi-channel multi-colour photometer MCCP mounted at the ESO 1-m telescope. Final fiber check by O. Bärnbantner.*

keep the satellites perfectly centred in the diaphragms for several hours.

According to the impact time predictions, only 3 events occurred during night time at La Silla (fragments B, F, V). Two additional fragments (L, U), which impacted during dawn, required of course clear skies for optical photometry. After the spectacular A impact observed in the IR from La Silla in the afternoon of July 16, we were optimistic to detect a flash signature during the impact of fragment B which was much brighter than A in images of the comet train. Half an hour before the predicted time we started to measure the surface brightness of Europa and Callisto every second. The individual data were displayed on-line on a graphic monitor to watch for any sudden brightness increase exceeding the photon noise level. Unfortunately, the observations were strongly affected by clouds which prevented on-line detection of any possible flash echo. Preliminary data reduction immediately thereafter did not reveal any significant peak in the light curves either.

The second event observable from La Silla during night time was the impact of fragment F. This time we set the fibers on Ganymede, Callisto and the sky, respectively. Though the post-impact plume caused by this SL-9 fragment was clearly detected by ESO observers in the IR, fast-moving clouds which partly reduced the visual transparency to only a few per cent, once again prevented on-line searching for an impact light echo.

As an example for the provisional data reduction performed immediately after observation, the raw I-band light curves of Ganymede(A) and Callisto(B) are displayed in Figure 2. They were increasingly affected by thick clouds during the predicted impact time interval. The reduced light curve of Ganymede(C) is plotted below. No flash signatures significantly exceeding the noise of the mean relative brightness (1 s $\sim$ 1 %) could be detected so far.

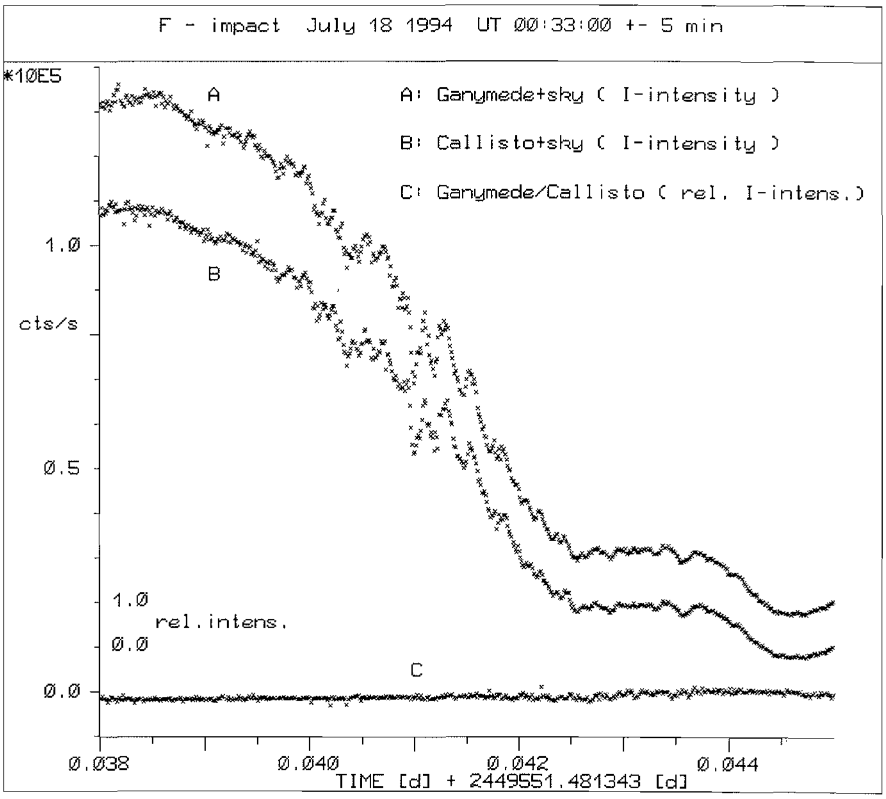

Figure 2: *Example of the standard reduction procedure: the relative brightness of Ganymede during the impact of fragment F.*

The remaining impact events observable from La Silla were much less favourable for a search for visual light-echo effects due to the low S/N during dawn and due to the fact that only the comparatively distant satellite Callisto could have been used as flash reflector. These photometric observations however failed because of unfavourable weather conditions.

Similar photometric programmes have also been performed by two other groups at La Silla using CCD cameras (PIs: K. Horne, B. Sicardy) and also by many other observers around the world. When their photometric data become available, a concerted effort will be made to search for probably very faint, coincident flash signals, which might still be hidden in individual light curves behind features that were otherwise thought to be artefacts of the different reduction procedures.

The faintness (or even absence?) of light echoes in optical light is nevertheless an important result from our observing campaign. Together with other data obtained world-wide during the SL-9 impacts, both from Jupiter itself and its satellites, it will certainly help to better understand the physics involved in such high-energy processes.

Near-Infrared Imaging of Comet SL-9 and Jupiter's Atmosphere

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The Max-Planck-Institut für Astronomie in Heidelberg kindly granted observing time at the ESO 2.2-m telescope during "German" time from July 16 to 24. During this run, Jupiter was observed with ESO's IRAC 2B near-infrared camera in the K band through interference filters and a tunable Fabry-Perot-interferometer (FPI) with resolution approximately 1000. This programme aimed at studying the interaction of the cometary fragments with Jupiter's atmosphere.

Regrettably, no impacts were observed. Apart from some wide-band im-