High-Speed Optical Spectro-Photometry of Jovian Satellites during Impact L Performed at Calar Alto Observatory

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1. Scientific Aim

Aim of this campaign was to detect light echoes from the impact of comet Shoemaker-Levy-9 on Jupiter. Different authors discussed possible phenomena of the impact: Sekanina (1994) proposed complete disintegration above the cloud layer of the Jovian atmosphere, whereas Ahrens et al. (1994), Zahnle and Mc Low (1994), Takata et al. (1994) and Boslough et al. (1994) discussed possible fireball plumes. Luminosities at an order of 10e23 - 10e25 erg/s were supposed to be released within a few seconds. As the impacts were not directly visible for earthbound observers, suggestions were made to try to measure reflections of the impact phenomena at the inner Jovian satellites. The aim of this campaign was to determine accurate impact timings and also to derive an estimate of the released energy from the brightness of the reflections. Similar attempts have been made by Barwig et al. (1994, 1995), Churyumov and Kleshchonok (1995), Consolmagno and Menard (1995), Ivanova et al. (1995) and Yanagisawa (1994). Of special interest are observations performed by Foryta et al. (1994), who did also high-speed photometry of impact L on Europa.

2. Observations

Observations were performed at Calar Alto Observatory (Spain) using the 2.2m telescope equipped with the high-speed multi-channel spectrophotometer MEKASPEK (Mantel et al. 1993, Mantel and Barwig 1994). This instrument allows to measure four sources simultaneously with a spectral resolution of about 50 throughout the whole optical wavelength range. The four sources are selected by four optical fiber bundles, which can be positioned by computer control in the focal plane of the telescope with an accuracy of 20um. The positioning device allows to apply individual track rates for each of the four targets. The four fiber bundles transfer the light of the four sources into a double prism spectrograph, which images the four spectra onto a 2D photon-counting detector (MEPSICRON). Spectra can be recorded with a maximum time resolution of 20ms. The MEPSICRON has a very low dark current of less than 4 cts/pix/hour and no readout noise. Due to the photon-counting mode, cosmic events just increase the dark current by one count and can therefore be neglected.

The L impact was the only one which could be observed during night time at Calar Alto observatory. The night before impact L was used in order to check the correct tracking of one of the Jovain satellites and to determine the amount of straylight caused by Jupiter. During impact L one fiber was used to track the Jovian satellite Europa, while a second one was positioned close by to measure the contribution from the sky background. Telescope guiding was done by guiding Jupiter with a CCD-camera and by applying additional track rates on the fiber used for Europa. The additional track rates were calculated from a table supplied by Montenbruck (1994).

Jupiter and the nearby full moon caused a large amount of additional straylight with a strongly variable gradient. This and the fact that the effect searched for was expected to be on a few percentage level at most, made it inevitable to use a small entrance diaphragm in order to keep contributions from the sky background and Jupiter as small as possible. Therefore an entrance diaphragm of 12" was used. An integration time of 0.5 seconds was applied. Although clear sky provided excellent observing conditions, the measurements were hampered by atmospheric refraction and dispersion caused by the relatively high airmass of 3.2 around the predicted impact time. A time check was done prior and after the observations by comparing the intrinsic instrumental clock with the observatory clock, which in turn is controlled by a GPS receiver. The accuracy of timings is better than 1 second. All times were recorded in UT.

Simultaneously to the high-speed spectrophotometric observations IR imaging and spectroscopy were performed at the 3.5m telescope with the MAGIC camera and visual imaging at the 1.23m telescope with a CCD camera. Results from these simultaneous observations are reported by Hamilton et al. (1995) and Herbst et al. (1995).

3. Results

Data were obtained as low resolution spectra with a time resolution of 0.5 seconds. In order to improve the signal to noise the data were binned into colour channels similar to the Johnson B, V, R colours. The background contribution was always less than 0.5%, the dark current was below 0.05%. The recorded data were corrected for the light travel time between Jupiter and Europa, which amounts to 3.2s at the time of impact L. Figure 1 shows the light curves in the B, V and R passbands around the impact time with the original time resolution of 0.5s. The data were divided by a smooth mean light curve in order to remove long term extinction features and to normalize the data. A gliding mean with a window of 3 was applied.

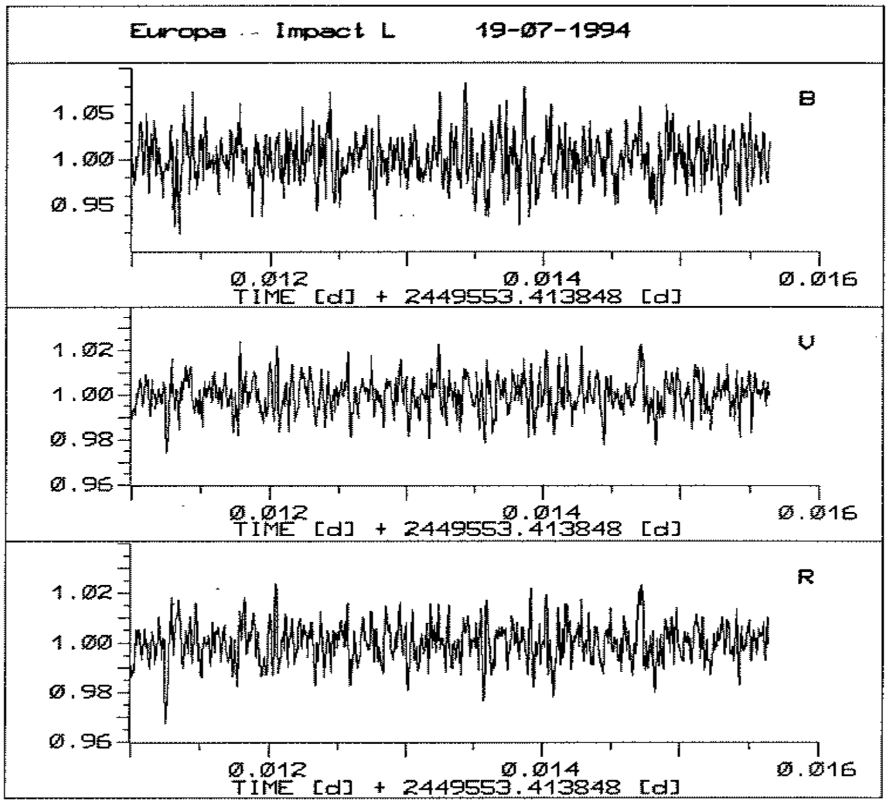

Figure 1: Original light curves in the B, V and R passband around the time for impact L.

There is a small feature in the light curve around 22:17:08 which is clearly to be seen in the red colour bands and which lasted for about 7 seconds. The brightness increase amounts to 2% in V and R colour band and is less pronounced in the blue than in the red. This feature is neither visible in the sky background and the dark current, nor is there a similar feature to be found in our whole data set. Although single spikes with a similar increase in brightness are visible within the data set, this feature shows a different structure as the whole intensity level increases for more than 10 successive integrations. Figure

2 shows this feature in more detail. In this figure the time when the Galileo spacecraft recorded a signal from the impact (Martin et al. 1995) is marked by a straight line. The times of start of precursor 1, sharp rise of precursor 1, peak of precursor 1, and rise of precursor 2 as observed with the MAGIC camera from the 3.5m telescope at Calar Alto observatory (cp. Hamilton et al. 1995) are marked by an asterix '*'.

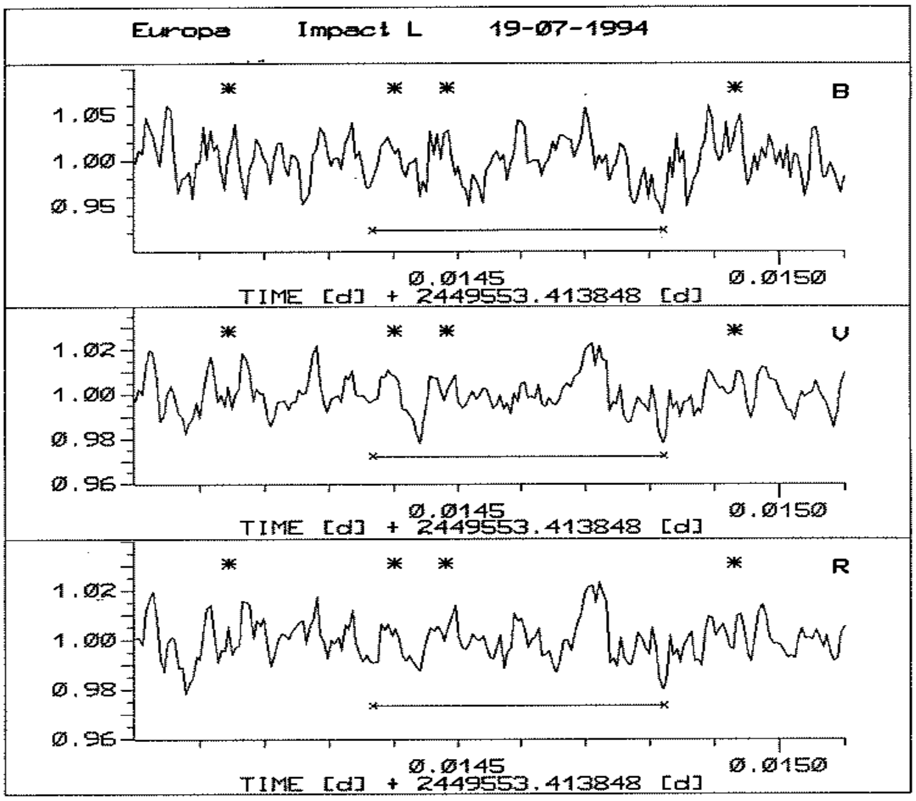

Figure 2: Detailed light curve in the B, V and R passband. The times for rise of precursor 1, sharp rise of precursor 1, peak of precursor 1 and rise of precursor 2 (cp. Hamilton et al. 1995) are marked by an asterix '*'. The time when the Galileo spacecraft recorded a signal is marked by a straight line.

Although the feature lies within the signal window of the Galileo spacecraft and instrumental effects and contributions form the sky background can be excluded as well, it is not yet clear whether this signal really represents the detection of a reflected flash at Europa. In order to proof this, a comparison between the data of Foryta et al. (1994) and the data presented in this paper is under work.

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