LONG-SLIT SPECTROSCOPY OF COMET
SHOemaker-LEVY 9 IMPACT SITES

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Abstract

Long-slit CCD spectra of the impact sites of Comet Shoemaker-Levy 9 were obtained at the
Nasmyth and coude foci of the 2.6 m telescope ZTSh of Crimean Astrophysical Observatory.
The Nasmyth spectra covered 4600–10,240 Å at a resolution of 4.5 Å. The coude spectra were
made at the CH₄ and Na absorptions with resolution 0.85–1.7 Å.

All the Nasmyth spectra were obtained along the crash latitude of Jupiter. Combined inves-
tigations of the extracted spectra along the impact parallel as well as spatial profiles at different
spectral regions show that the impact sites have some spectral peculiarities. In addition to the
well seen absorption in the impact sites over observed wavelength region and decreasing of the
CH₄ absorptions near 8900 Å and 1 μm, moderate weakening of the CH₄ band at 7200 Å and
NH₃ band at 7900 Å was detected in some observed spots as well.

The coude spectra showed weakening of the CH₄ features, but lack of any variations in the
Na lines.

1 Introduction

Recent collision of the Comet Shoemaker-Levy 9 with Jupiter was one of the most dramatic events
occurred in the solar system. For the first time such a catastrophe was predicted and extensively
studied by astronomers over the world.

Observations clearly showed that impact sites of the cometary fragments are in absorption in
optical wavelength region and hot in the 8900 Å and other IR CH₄ bands related to undisturbed
regions. Other peculiarities, such as new chemical compounds, plumes, and flashes, were observed
immediately following the impacts during a short period. Expected reflections off the Jupiter’s
satellites were found very weak.

Because of imperfect understood of the repercussions of the Shoemaker-Levy 9 collision with
Jupiter spectral observations were good to obtain the most peculiarities of this impact.

2 Observations and data reduction

We made long-slit CCD spectroscopic observations using the 2.6 m telescope ZTSh of Crimean
Astrophysical Observatory. We observed impact sites on Jovian disk at the Nasmyth focus in wide
spectral region and in some narrow wavelength regions at the coude focus.

The CCD “Ista” camera with 580 × 520 pixels was used as a detector at the Nasmyth focus (Beriozin
et al, 1991). Each CCD pixel has the dimensions 24×18 μm² which corresponds to 0.7 arc sec in
spatial direction and 2.2 Å along dispersion. The composite spectra covered 4600–10,240 Å. To
construct them we obtained a set of spectra for different wavelength regions with overlap sections
along dispersion. The spectrograph slit was oriented along the parallel of impact to provide a spatial
analysis in this direction. The width of the slit was 0.5 arc sec on the plane of the sky and 1900 km on Jupiter's surface; the height was large enough to cover the parallel of interest.

We obtained 17 long-slit spectra along the crash latitude and their observational parameters are given in Table 1. We observed the HD117176 star as a standard one each night. The calibration of HD117176 one can find in Kharitonov et al. (1988).

Long-slit coude spectra were obtained by the use of the CCD camera with 600×480 pixels, produced by ASTROMED (Huvelin, at al., 1986). The scale of this device is 0.15 arc sec/pixel, and dispersions are 0.027 Å/pixel and 0.054 Å/pixel at the third order and the second order, respectively. More detailed information on these observations is summarized in Table 1.

The distinctive property of our observations at the coude focus was the lack of an image derotator. Since orientation of the slit during exposures was not maintained, distribution of the intensity along the slit was corrupted. So, we made analysis of the peculiarities of the impact sites only along dispersion.

The CCD frames were first flat-fielded to correct for the nonuniform sensitivity of the CCD elements, and then the sky background, determined near the slit edges, was subtracted. Furthermore, the wavelength were calibrated using He-Ne-Ar and Th-Ar lamps.

It should be noted that all observed Jovian spectra are prepared using FITS format with detailed log on our observations in their FITS-headers.

<table>
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<tr>
<th>CCD image</th>
<th>Date (UT), July, 1994</th>
<th>Exposure, s.</th>
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<th>Wavelength region, Å</th>
<th>Observed spots</th>
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Figure 1: Peculiarities of the K spot.
Figure 2: Coude spectrum of the EFTV spot and ratio spectra of the KUW and EFTV spots.
3 Nasmyth spectra

To localize the impact sites we started our investigations of the reduced spectra with the analysis of the spatial profiles in different wavelength regions.

Our observations clearly showed that the spots were in absorption over all observed wavelength region. In the blue region absorption in the giant spots was as much as 40% (spot DGRS), and was reduced to several percents to the red.

The opposite effect was in the near-infrared methane bands at 8900 and 10,000 Å. In these wavelengths regions the impact sites were seen as hot spots. Since the spots were observed during many rotations of Jupiter, the weakening of the methane bands was caused by variation in Jovian aerosol and/or decreasing of the abundance of methane in the impact sites, rather than by excitation of the methane molecules.

Spatial variation of absorption in the 8900 Å CH₄ band related to the K impact site one can see in Fig. 1 (top). To obtain this result we extracted spatial profile of the CH₄ absorption at 8900 Å and divided them by spatial profile in the closest continuum. To use undisturbed profile in the 8900 Å band would be more valid, but we had no this one.

It is seen, that the spot K are located near the central meridian of Jupiter and occupied about one third of the observed parallel. Weakening in the central part of this impact site gets to 21%.

The ratio spectrum spot/undisturbed site obtained for the 8900 Å CH₄ band is plotted in Fig. 1 (bottom). To derive them we had divided the spot spectrum by that of undisturbed site. Moreover, we normalized the obtained ratio to 1 in the continuum near 8900 Å. Since we had no observations of the undisturbed impact parallel of Jupiter, we compared the extracted spectrum of the impact site with that of adjacent undisturbed surface.

The most prominent decreasing of the 8900 Å absorption with respect to undisturbed surface we observed in the impact site L, it was about 48%.

Analysis of the spatial profiles gave the locations of the spots and undisturbed sites along the observed parallel for each two-dimensional spectrum. In addition, examination of the spatial profiles pointed to the fact that there are peculiarities of the impact sites spectra with respect to undisturbed surface.

Well seen spectral peculiarities along dispersion were investigated previously (Korsun, et al., 1995). It was shown that all observed spots were hot in the 8900 Å CH₄ band. The same was detected in the 1 μm CH₄ band in the DGRS and L impact sites. In addition, we pointed out that the ratio spot/background spectra have different gradients in giant spots and medium-sized ones.

Under more careful investigations of the ratio spectra we detected some more spectral peculiarities in the observed spots. It turns out that decreasing of the Jovian absorptions is inherent in the other molecular bands. Such an effect was present in the CH₄ band at 7200 Å (spots K, L, N, and DGRS) as well as in the NH₃ band at 7900 Å (spots L, H, N, and DGRS).

4 Coude spectra

Our coude observations were successful on July 22, 1994. We made two exposures of the KUW impact site in the CH₄ and Na absorptions, and one more of the EFTV impact site in the CH₄ absorption.

To obtain spectral peculiarities of these impact sites we used the same procedure as in the case of the Nasmyth observations. Namely, we extracted the spectrum of the spot and that of the adjacent undisturbed site, and obtained a ratio spectrum by division the first of them by the next.

We had not detected any variations in the Na spectral lines at the time of observations. Analysis of the CH₄ spectra, obtained in the 8884–8944 Å wavelength region, showed weakening of the CH₄ features both in the KUW impact site and in the EFTV one. A coude spectrum of the methane
associated with the KUW impact site one can see in Fig. 2 (top). Spot/background ratio spectra for both spots are presented in Fig. 2 (bottom). These latter show prominent weakening of the CH$_4$ spectral features, which amounts to as much as 25%.

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References


