

Optical spectroscopy of comet C/2007 N3 Lulin

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ABSTRACT

We report the results of optical CCD spectroscopy of the comet C/2007 N3 Lulin on February 19th 2009, when it was at a geocentric distance of $\Delta=0.45$ AU. Lulin passed its perihelion on January 10th 2009. The wavelength range from 3700 to 8000 Å showed a prominent emission band of the CN(0-0) detected at 3880 Å. Also, the forbidden oxygen [O I] emission line at 6300 Å is clearly visible. From a comparison of these and other reported observations, such as for example comet C/1995 O1 Hale-Bopp made by A. Fitzsimmons and I. M. Cartwright and others made by U. Fink and M. D. Hicks, C/Lulin appears to be a normal comet, albeit highly active.

I. INTRODUCTION

Comet C/2007 N3 Lulin (Fig. 1) was discovered on July 11th 2007, at Lulin Astronomic Observatory on Taiwan island, by a team of astronomers under the supervision of professor Quanzhi Ye (Sun Yat-sen University), when the comet was at a visual magnitude of ≈ 18.9 . On February 19th 2009 Lulin was located in the Virgo constellation, near Spica (Fig. 2), at a visual magnitude of 6.1. The results of the optical spectroscopic observations of C/Lulin show the chemical composition of the comet.



Fig. 1: Picture of C/2007 N3 comet.

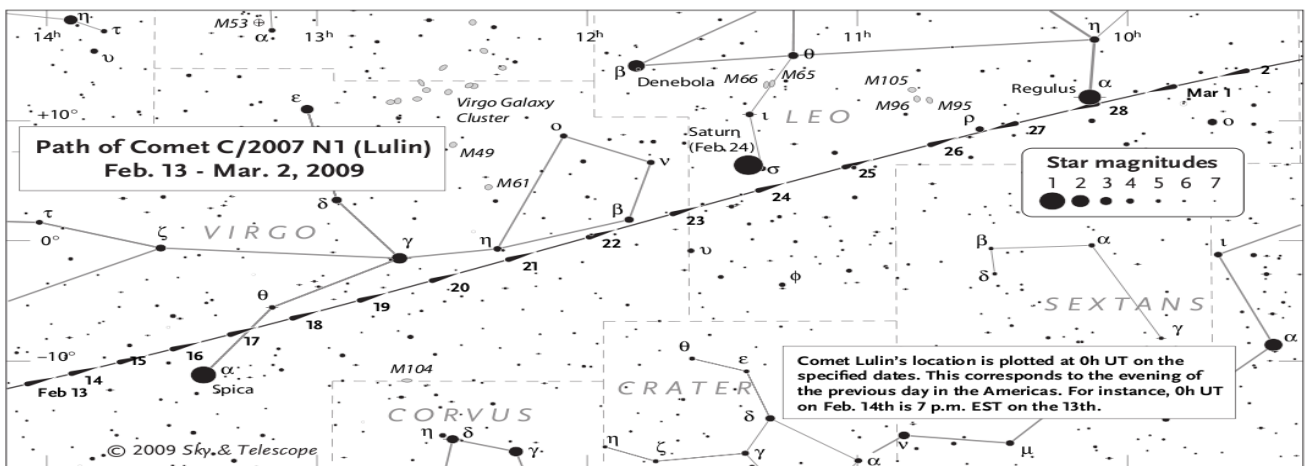


Fig. 2 Sky chart reporting the position of the comet.

II. OBSERVATIONAL DATA

We studied the C/2007 N3 Lulin comet with a Boller & Chivens spectrograph, mounted at the 122 cm telescope (F=1950 cm, Cassegrain) of the Asiago Astrophysical Observatory. A slit width of 2.5 arcsec resulted in an instrumental resolution of ≈ 10 Å.

The exposures were obtained when the position of the comet was RA = $12^h49^m35^s$ and DEC = $-04^\circ51'13''$. We had to wait until 01:00 UT to let the comet rise and observe it. The sky spectrum, which had to be subtracted from the comet one, was taken pointing the telescope at a distance that allowed us to observe it outside the coma.

III. WORK DESCRIPTION

For our observations, three 180s exposures of the comet's nucleus (Fig. 3) were obtained from 01:22 UT to 01:34 UT. During the three exposures we had to maintain the nucleus centred on the slit manually. We had to do this because, like all other comets, Lulin has got its own motion. For the spectroscopy of the coma we applied an exposure time of 300 seconds.

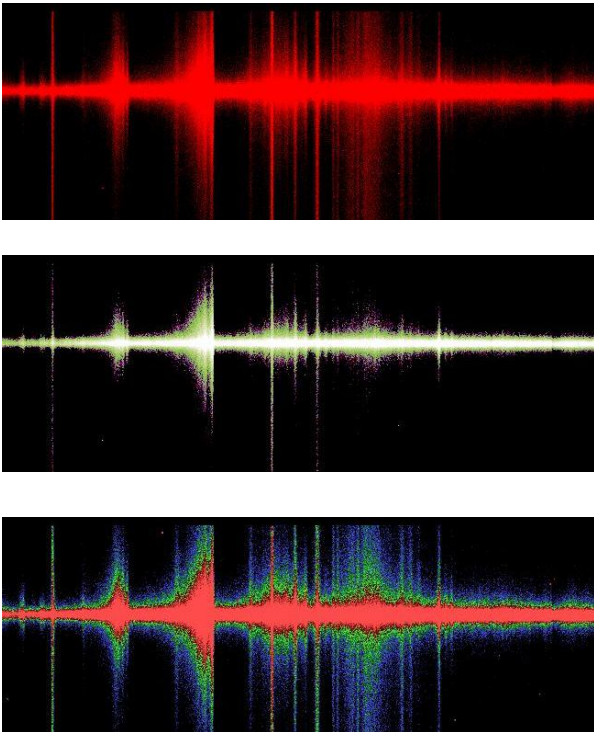


Fig. 3: The three spectra of the comet obtained at the 122 cm telescope of the Asiago Astrophysical Observatory.

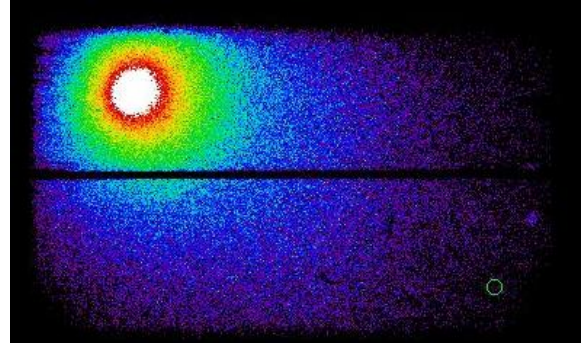


Fig. 4: Image of the Comet C/2007 N3 Lulin obtained through the guiding camera of the spectrograph.

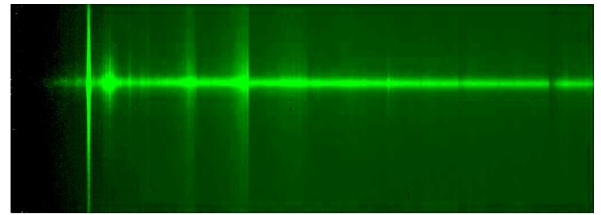


Fig. 5: Spectrum resulting from the sum of the three exposures.

We used the IRAF astronomical package to reduce the observed spectra with a standard reduction procedure. First of all, the raw spectra were bias subtracted and flat-field corrected. In order to convert pixel values along the dispersion axis into Angstrom units, we used spectra of comparison lamps, emitting lines at known wavelength. Spectrophotometric standard stars, whose energy distribution as a function of wavelength is known, were observed and measured to convert photon counts into energy, measured in $\text{erg}/\text{cm}^2/\text{s}/\text{\AA}$.

Once completed this procedure, we obtained the spectrum of the comet expressed in physical units, then we subtracted the night-sky spectrum in order to eliminate light and spectral features produced by our atmosphere. Finally, we summed together the three spectra to increase the signal and the quality of the data of the nucleus.

IV. RESULTS

We compared the resulting spectrum with those of other comets, as comet C/2001 A2 LINEAR, to identify the emission features (lines and bands). We found the following elements: CN, C₃, CH, C₂, NH₂ and [O I], and absorption lines H β and H α .

The production rate of H₂O ($Q[\text{H}_2\text{O}]$) could be determined from [O I]6300 luminosity ($L(6300)$) by:

$$Q(H_2O) = L(6300) \cdot \frac{\sum A_{ki}}{A_{ki}} \cdot \frac{k(H_2O)}{k(OI)}$$

$$Q(H_2O) = L(6300) \cdot 1.330 \cdot \frac{12.0 \cdot 10^{-6}}{1.0 \cdot 10^{-6}}$$

$$Q(H_2O) = L(6300) \cdot 16$$

where $Q(H_2O)$ is the water production rate per second, $L(6300)$ is the luminosity of [O I] emission at 6300Å,

the branching ratio $\frac{A_{ki}}{\sum A_{ki}}$ is the transition probability of the 6300Å line from the [O I] 1D level divided by the sum of all transitions from that level (essentially the 6364Å line). Although values for the mean life of this level range from 101s to 148s, (Wiese *et al.* 1966; Mendoza 1983; Froese-Fischer and Saha 1983), the branching ratio to the 6300Å line is consistent within a few parts per thousand, so there should be little uncertainty in that number.

The second branching ratio $\frac{k(OI)}{k(H_2O)}$ represents the production of [O I] atoms in the 1D state divided by the total photon destruction rate of water. There is a reasonable agreement for a value of $12 \pm 0.5 \cdot 10^{-6}$ for the total water destruction rate (e.g., Huebner and Carpenter 1979; Festou 1981; Crovisier 1989; Fink and DiSanti, 1989).

In our case:

$$Q(H_2O) = L(6300) \cdot 16$$

$$Q(H_2O) = 4\pi d^2 \cdot \varphi_{photons} \cdot 16$$

$$Q(H_2O) = (5.73 \cdot 10^{22} \cdot 2850) \cdot 16$$

$$Q(H_2O) = 2.61 \cdot 10^{27} \text{ molecules of } H_2O \text{ per second.}$$

Comparing our data with the ones from other observations, we found out that we should use 0.07, instead of 16, to multiply the luminosity of CN and find out the production rate of CN:

$$Q(CN) = L(6300) \cdot 0.07$$

In this case:

$$Q(CN) = 1.59 \cdot 10^{27} \cdot 0.07 = 1.11 \cdot 10^{26} \text{ mol} \cdot \text{s}^{-1}$$

The branching ratio $\frac{Q(CN)}{Q(H_2O)} = 0.042$

If we apply the same procedure to the spectrum of the coma we find out that the branching ratio $\frac{Q(CN)}{Q(H_2O)}$ is almost six time larger than the nucleus' one.

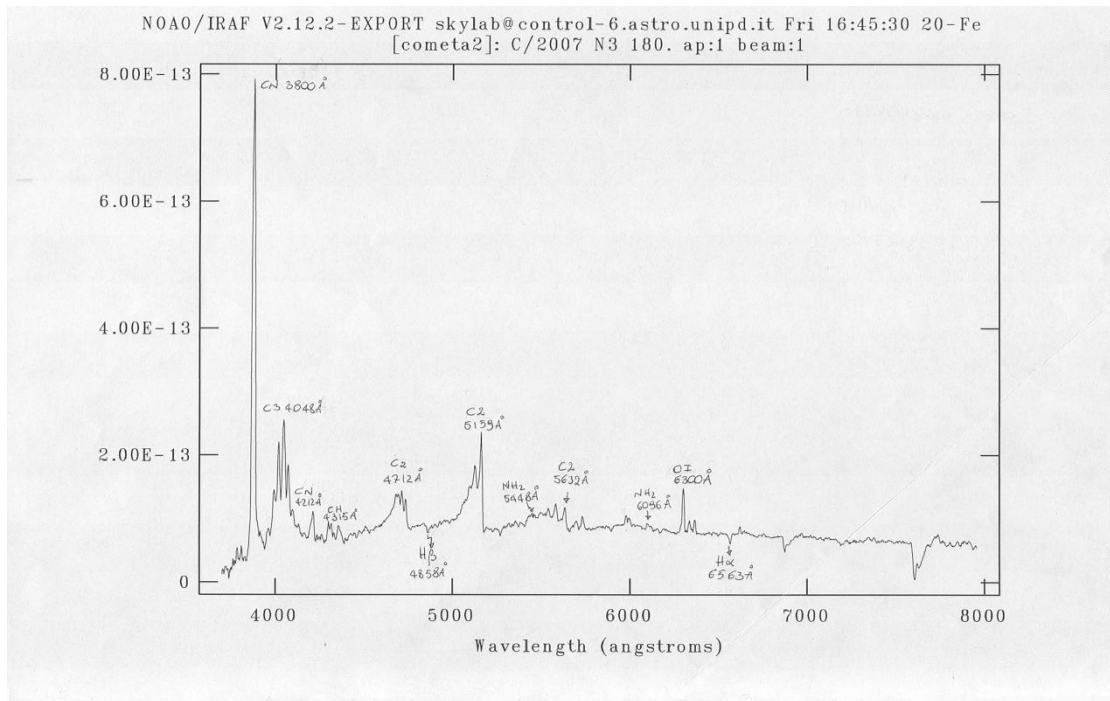


Fig. 6: Spectrum of the comet with identified spectral features.

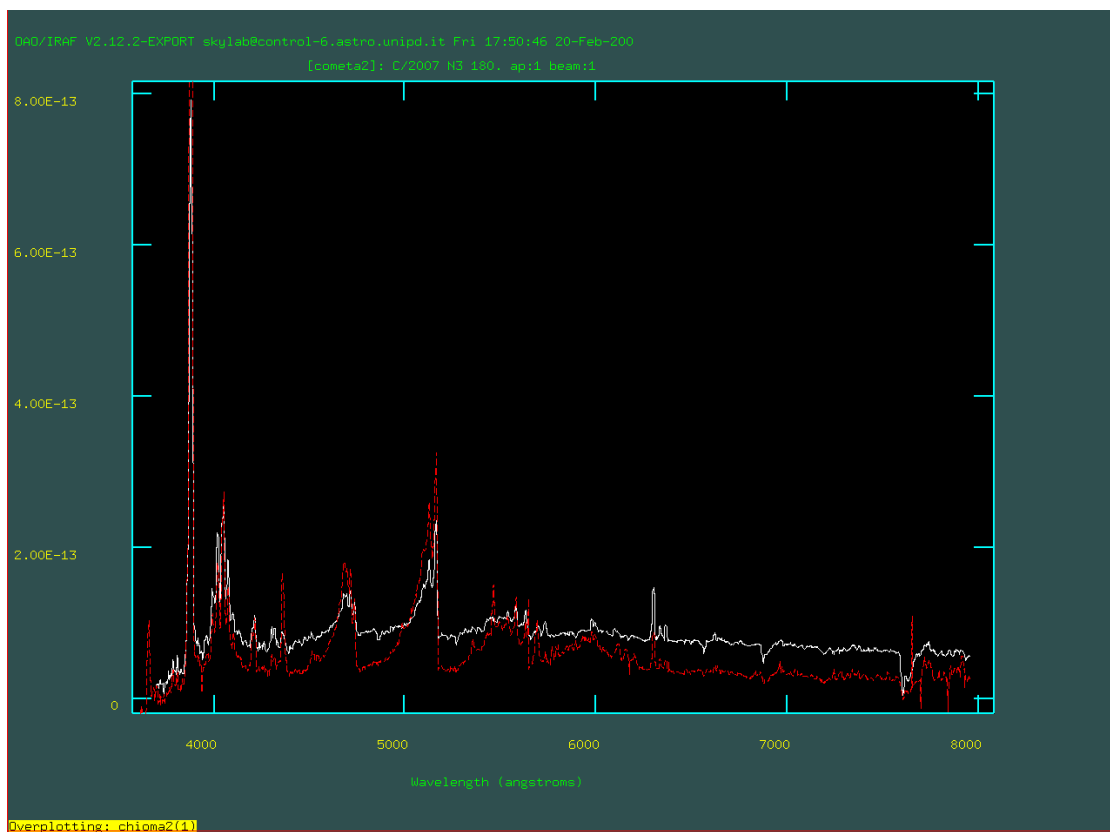


Fig. 7: Coma's spectrum (red) over nucleus's spectrum (white).