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OBSERVATIONS OF COMET LEVY 1990c IN THE [OI] 6300-Å LINE WITH AN IMAGING FABRY-PEROT

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ABSTRACT

We have observed the comet Levy 1990c during 16-25 August 1990 using the MPAE focal reducer system based Fabry-Perot etalon coupled with the 1 meter telescope of Observatory of Hoher List. The free spectral range and resolution limit of the interferometer was $\sim$ 2.18 Å and $\sim$ 0.171 Å respectively. Classical Fabry-Perot fringes were recorded on a CCD in the cometary [OI] 6300 Å line. They are well resolved from telluric air glow and cometary NH_2 emission. Our observations indicate that the [OI] is distributed asymmetrically with respect to the center of the comet. In this paper we report the spatial distribution of [OI] emission and its line width in the coma of comet Levy.

INTRODUCTION

The mapping of [OI] 6300Å emission in the cometary coma provides information about the distribution of its source O^1D, which is a major dissociation product of H_2O. The earlier studies of the cometary spectrum in 6300Å region mostly used high resolution grating spectrometers and central aperture scanning Fabry-Perot (FP) spectrometers (Arpigny et al., 1987, Combi and McCrosky 1991, Magee-Sauer et al., 1989, Debi Prasad et al., 1988). Whereas the high resolution grating spectrometers provide the one-dimensional distribution along the slit, the central aperture scanning FP averages across the field of view. The FP in imaging mode has been used by Magee-Sauer et al. (1988) to map the O^1D distribution in the inner coma region and, with limited signal to noise ratio, Debi Prasad and Desai (1989) have derived the velocity information. We have used the Fabry-Perot interferometer in classical mode and recorded the fringe system in wide field of view with a focal reducer and CCD. This paper reports the 6300Å line width and intensity distribution in the coma of comet Levy.

OBSERVATIONS AND DATA ANALYSIS

Comet Levy was observed with MPAE focal reducer based FP interferometer and CCD camera (Jockers et al, 1987) which can be rapidly switched between the imaging and interferometric mode. The free spectral range, resolution limit and optical gap of the FP interferometer derived from the spectral lamp calibration frames at the time of observation are 2.2Å, 0.12Å and 905.45 micron respectively. The field of view and spatial resolution of the focal reducer are 29×20 arcmin and 3.0 arcsec pixel^{-1} respectively. The observations of August 1990, 17.95 UT are reported here. During the observations the cometary heliocentric (r_h) and geocentric distances are 1.48 and 0.51 AU respectively. The geocentric velocity was -30.7 km/s, which corresponds to 0.64 Å Doppler shift of cometary line with respect to the terrestrial line at 6300Å. The focal reducer images of comet Levy in 6300Å filter (I_{L+C}) were obtained with the FP etalon in the collimated part of the optical path. The FP etalon was removed while exposing for the continuum images (I_C) with 6420Å pre-filter. The images of a diffuser screen illuminated by a continuum source were taken with and without FP etalon. The ratio of these two bias subtracted images normalized to unity with the average counts in the central region of the frame, (I_R) serves for correcting distortion in intensity distribution that might be caused by introducing the FP etalon. The position of the comet in CCD pixel coordinate was the same during interferogram and imaging exposures.

The images are bias subtracted and flat-field corrected. In I_{L+C} the airglow, cometary lines and continuum light is convolved with the periodic Airy function with the instrumental finesse 19

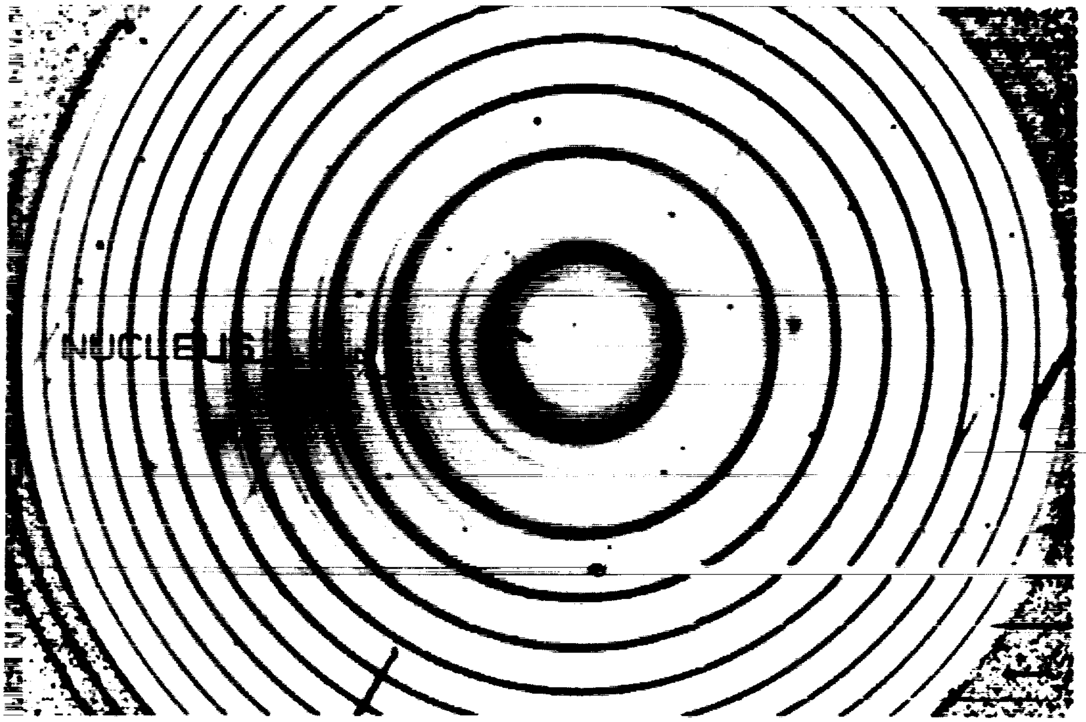

Figure 1: Fabry-Perot Interferogram of Comet Levy in 6300Å. The bright points not marked by arrow are due to instrumental reflections. Sun is to the left.

which is determined from the spectral lamp calibrations during the observations. The airglow and cometary profiles are broader than the instrumental profile. We have computed the Airy function with degraded finesse in order to fit the telluric and cometary O^1D emission. The best fit of Airy function with the observations was obtained for the effective finesse of 16 and 13 in the case of airglow and cometary emission. This indicates that the cometary lines are broader than the airglow. The FP interferogram due to the emission lines I_L obtained by using the relation,

$$I_L = (I_{L+C}) - (I_R \times I_C) \qquad (1)$$

is shown in Figure 1. The full circles are due to the airglow and partial circles are due to the cometary emission. The cometary [OI] 6300Å is readily identified as the fringes are Doppler shifted from the airglow corresponding to its geocentric velocity. With respect to the cometary [OI] line the other cometary lines listed by Combi and McCrosky (1991) are identified by taking into account of the filter transmission and free spectral range of the FP. Further the inter-order overlap of the cometary lines transmitted by the pre-filter was also taken into account for the identification of NH_2 lines. Figure 2 shows an example of the radial scan from a part of the interferogram within one free spectral range corresponding to the two inner circles of the interferogram. The observed FP profile was divided by the computed instrumental transmission function for airglow and cometary [OI] emission in order to take into account the FP modulation. The absolute calibration is made by observing the the spectrophotometric standard star (29 Vul) with the pre-filter and FP etalon. The effect of FP etalon on the observation of the standard star have been taken into account. The calibrated cometary [OI] flux is extracted from four sectors A, B, C and D with respect to the center of the comet as shown in Figure 3. The sector A is in the tailward hemisphere and sector B is in the sunward hemisphere of the comet. The error in estimating the absolute values in [OI] intensity is $\sim 30\%$. The relative error in intensities is much smaller and does not exceed $\sim 10\%$.

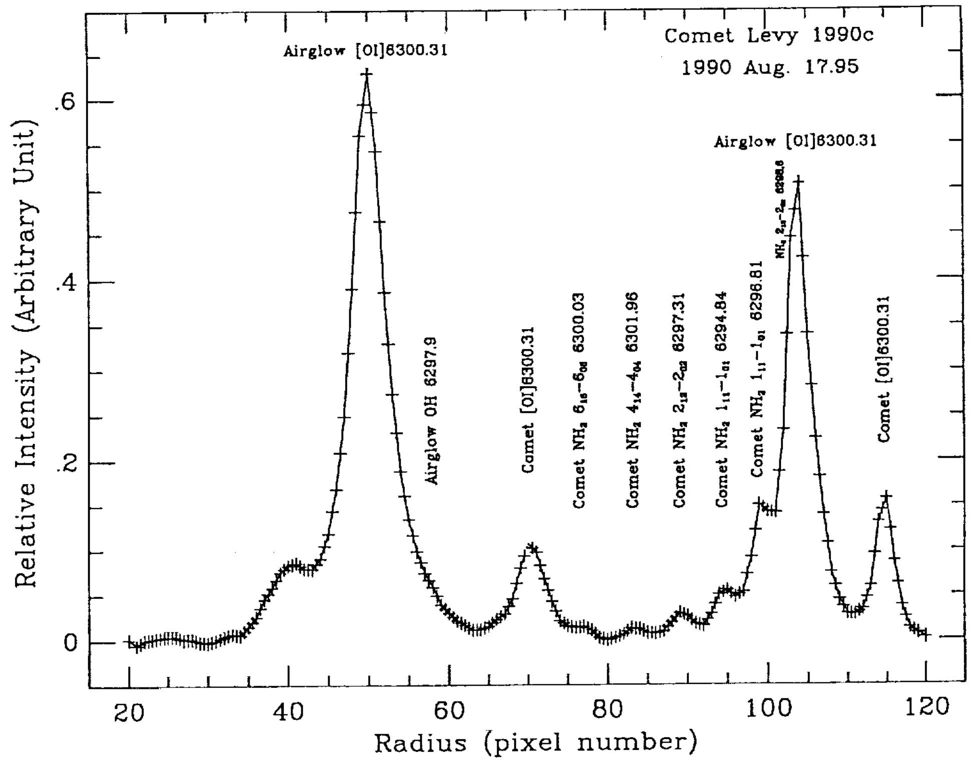

Figure 2: Radial scan within two inner circles of the interferogram

RESULTS AND DISCUSSION

The line profile analysis show that, in general the cometary [OI] emission line is wider than the airglow profile. In a selected area of 3×24" (3×29 10^3 km) with the long side perpendicular to the fringe, at cometocentric distance of 2.2×10^5 km in the sunward side, we find the half width at half maximum to be 2.25 km/s. This refers to the outflow speed of oxygen atom within the field of view of the cometary atmosphere, since the natural width of O^1D line is small. Our values are slightly higher than similar measurements in the case of comet Kohoutek and Halley (Huppler et al, 1975, Magee-Sauer et al, 1988, Debi Prasad et al, 1988). However, the earlier measurements have used a large field of view, as a result, the contribution from the low velocity component at the near nucleus region is dominant in these signal. On the other hand, our data corresponds to a narrow field of view, isolating the signal from from the near nucleus region. The dusty-gas-dynamic Monte-Carlo model by Combi (1989) in case of comet Halley predicts an outflow speed of 0.91 km/s at a heliocentric distance of 1.5 AU in the post-perihelion epoch within the collision zone. According to this model the expected velocity at the distance of our measurements is $\sim$ 1.5 km/s.

We have traced the cometary [OI] emission up 3×10^5 km from the nucleus of comet Levy as shown in Figure 3. Our data show an approximate r_h^{-1} distribution of O^1D within a radial distance of 1.2×10^5 km from the nucleus which is close to the photo-dissociation scale length of water at the heliocentric distance of our observation, beyond which the distribution is flat. Earlier the [OI] distribution have been reported up to $\sim 10^5$ km from the nucleus (Magee-Sauer et al, 1988), with which our results are in agreement. The flat distribution beyond the photo-dissociation scale length of water could be due to the parent molecules with longer life time such as CO and CO_2. A sunward to antisunward asymmetry in the distribution of [OI] emission is noticeable up to a cometocentric distance of 10^5 km beyond which the signal is not strong enough. As in case of comet Halley (Combi and McCrosky, 1991) the observed asymmetry can be understood as the

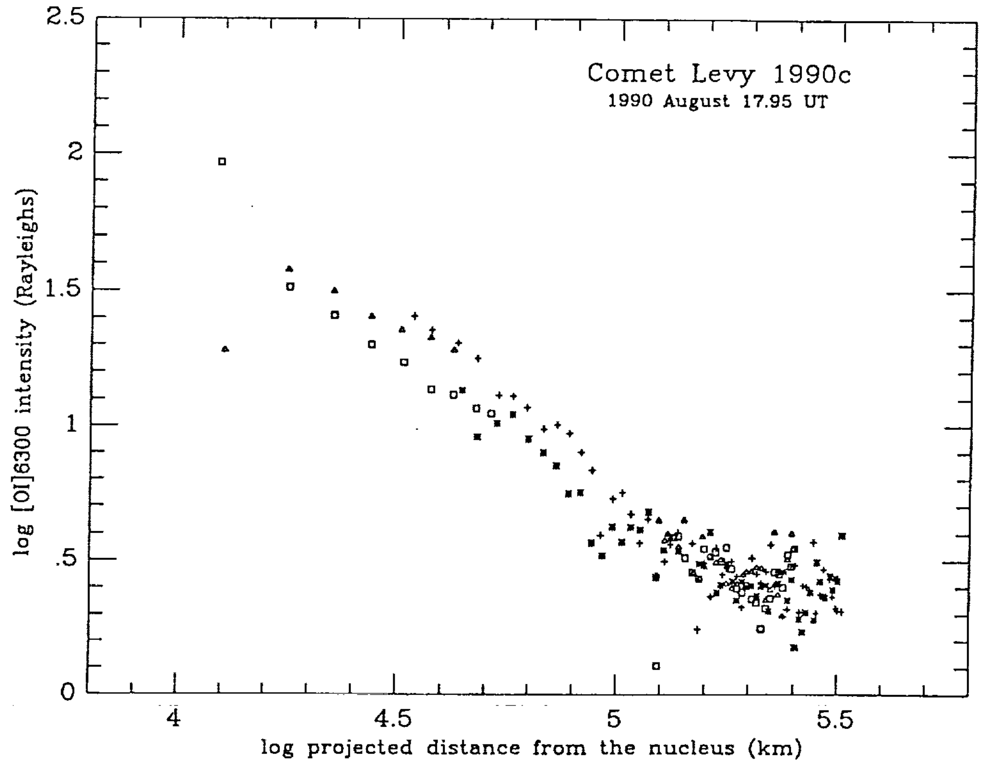

Figure 3: Distribution of cometary [OI] 6300Åemission from four sectors of the interferogram (△:A; +:B; □:C, ∗:D). See text for the explanation of different sectors.

result of preferential sunward ejection of material from the cometary nucleus. The inner coma imaging of comet Levy with the Hubble Space Telescope, indeed reveal a fan-shaped inner coma in which the sunward facing hemisphere is significantly brighter (by a factor of ~2.5) than the tailward hemisphere (Weaver et al, 1991), consistent with our observations.

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