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Results from two unusual comets C/2016 R2 (Pan-STARRS) and C/2015 V2 (Johnson)

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Abstract

A typical optical spectrum of a comet with well developed coma shows molecular emissions dominated by carbon chain molecules. The Oort cloud comets C/2015 V2 (Johnson) and C/2016 R2 (Pan-STARRS) were spectroscopically followed and observed using a low resolution spectrograph (LISA) mounted on the 1.2m telescope at the Mount Abu Infrared Observatory (Mount Abu, India) during the period of December 2016 to Feb 2016 and in January 2018 respectively. Our observations and studies revealed that the optical spectra of these two comets are quite unusual as compared to general cometary spectra. Most of the major cometary emissions like C2, C3 and CN were absent in comet C/2016 R2. However, the comet spectrum showed very strong emission bands from ionic species like CO+ and N2+. The N2/CO ratio was determined from the spectra and an extremely low depletion factor of 1.6 has been estimated. In comparison, the optical spectrum of comet C/2015 V2 was also devoid of any kind of molecular emissions and the major cometary species were absent when the comet was observed at a heliocentric distance of 2.83 AU. However, no other emissions were detected (like that of the ions detected in R2). Regular cometary emissions in comet V2 were detected after 2.3 AU, although the productions rates remained much lower as compared to other active Oort cloud comets. The unusual spectra of these comets may be the consequence of their distinctive processing at the location of formation in the early solar nebula.

1 Introduction

In general molecular emissions in a comet start appearing sequentially when the comet comes closer than 3 AU [Krishna Swamy, 2010] to the Sun. The most likely emission to appear first is that of CN molecule at around 3 AU, followed by the rest of the emissions. There are very few comets in which emissions are reported beyond 3 AU and even fewer beyond 5 AU. Ionic emissions like CO^+ and N_2^+ are rarely seen in the coma of a comet. They are however abundantly found in the plasma tail of comets. One such comet, from which CO^+ emissions were detected in its coma was 1962 VIII [Arpigny, 1964], also known as comet Humason. Lot of work [e.g. Voelzke et al., 1997; Guineva et al., 1999, 2000; Jockers et al., 1987] has been carried out based on the CO^+ emissions that were found in the coma and tail of Comet 1P/Halley.

In this work, we have obtained and analysed the optical spectrum of two Oort cloud comets C/2016 R2 (PanSTARRS) ('R2') and comet C/2015 V2 (Johnson) ('V2'). R2 was discovered by PanSTARRS on September 7^{th} 2016, whereas V2 was discoverd by Jess Johnson on 03^{rd} November 2015. The comet R2 brightened to a magnitude of 13 in visual band in January 2018. It has an orbital eccentricity of 0.996, semi-major axis of 738 AU, orbital inclination of 58 deg to the ecliptic and a total orbital period of 20084 years and a perihelion distance of 2.6 AU (may 2018). Comet V2 has an eccentricity of 1.001, semi-major axis of 976 AU, orbital inclination of 50 deg to the ecliptic.

2 Observations and Reductions

The observations were carried out with LISA spectrograph mounted on the 1.2 m(f/13) telescope (PlaneWave Instruments CDK20) at the Mount Abu Infra-red observatory (MIRO), Mount Abu, India. The sky conditions were photometric during the observing period.

Details of the comet observations are given in table 1. The exposure times mentioned in the table are for each individual frame. A more detailed description of the instrument LISA is given in Kumar et al. [2016]. The slit was placed at the photo-center of the comet and was manually tracked through the guiding CCD throughout the exposure time. The observations were

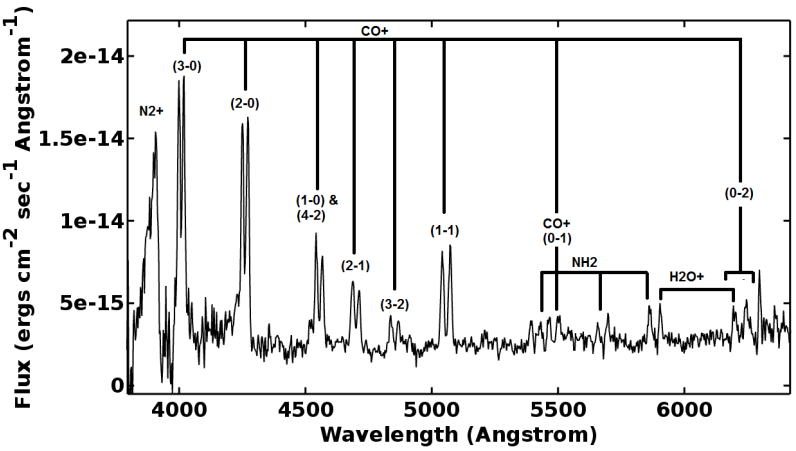

Figure 1: The optical spectrum of comet C/2016 R2 (Kumar et al.2018, submitted to A&A) taken on 25th January 2018 using LISA spectrograph on 1.2m telescope at the Mount Abu Infra-red observatory, Ahmedabad. All the major emission lines are marked

Table 1: Observational Log

Comet	Date	Heliocentric Distance r_h (AU)	Solar Phase (degrees)	Exposure (Seconds)
R2	25/01/2018	2.87	15	1800
V2	10/12/2016	2.83	130	1200

made using the scheme, sky-object-sky, for the proper background sky subtraction.

3 Results and Conclusion

Our observations and studies revealed that the optical spectrua of comets R2 and V2 are quite unusual as compared to general cometary spectra. Most of the major cometary emissions like C_2, C_3 and CN were absent in comet R2. However, the comet spectrum showed very strong emission bands from ionic species like CO^+ and N_2^+. The N_2/CO ratio was determined from the spectra and an extremely low depletion factor (with respect to the solar nebula value) of 1.6 ± 0.4 has been estimated. This depletion factor is much lower than Our estimation of the N_2/CO ratio obtained with the low resolution spectra (Kumar V et al., 2018, submitted to A&A) is well in agreement with those reported by Cochran & McKay [2018] using high resolution spectra. The column densities and production rates of CO^+ and NH_2 were calculated from their emission bands which were of the order of 10^{24} molecules sec^{-1}.

The major cometary species were also absent in comet V2, when it was observed at a heliocentric distance of 2.83 AU. However, no other emissions were detected (like that of the ions detected in R2). The optical spectra of this comet was obtained at various epochs using LISA on the 1.2m telescope at Mount abu. The regular cometary emissions were detected after 2.3 AU. The extremely low activity of comet V2 suggests a resemblence with comets like C/2014 S2 [Meech et al., 2016] which are classified as Manx objects (Inactive objects in comet like orbits).

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