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# High resolution spectroscopy of the unusual comet C/2016 R2 (PanSTARRS)

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## Abstract

We report on high spectral resolution observations of the peculiar comet C/2016 R2 (Pan-STARRS). This comet was found to have a highly unusual composition, with a very high abundance of CO, and is only the third comet in which the $N_2^+$ ion is clearly detected. Our observations allowed us to measure the $N_2^+/CO^+/CO_2^+$ ratios. Among other things, we also put an upper limit to the $^{14}N/^{15}N$ isotopic ratio, measured for the first time directly from $N_2^+$, and detected the [NI] lines for the first time in a comet.

## 1. Introduction

The long period comet C/2016 R2 (Pan-STARRS) was discovered on September 7, 2016 at 6.3 au from the Sun. In December 2017, it was found that the coma emission of the comet was surprisingly dominated by $CO^+$ and $N_2^+$ [1], while most of the emission bands usually detected in the optical spectrum of comets were hardly visible. Prior to this detection, the presence of the $N_2^+$ molecule has only been confirmed in the coma of three comets: C/2002 VQ94 (LINEAR) [3], 67P/Churyumov-Gerasimenko [5], and 29P/Schwassmann-Wachmann 1 [2]. From the $N_2$/CO abundance ratio measured in 67P, it appears that molecular nitrogen is highly depleted in comets compared to the proto-solar value, which has implications on their formation. The detection of bright $N_2^+$ emission lines in the coma of comet C/2016 R2 represented a rare opportunity to enlarge the sample of comets for which we have a measurement of the $N_2^+/CO^+$ ratio, but also to determine for the first time the $^{14}N/^{15}N$ isotopic ratio directly from $N_2^+$. We thus decided to observe comet C/2016 R2 with the UVES instrument at the VLT, in order to obtain a high-resolution spectrum of the comet over the full optical range.

## 2. Observations and data reduction

We obtained a total of 6h of observations of comet C/2016 R2 (Pan-STARRS) with the VLT UVES high resolution spectrograph, between February 11 and February 16, 2018. We used two different UVES standard settings to cover the whole optical spectrum. The 390+580 setting (ranging from 326 to 454 nm in the blue and from 476 to 684 nm in the red) allowed us to secure a high SNR ratio measurement of the $N_2^+$ and $CO^+$ emissions while the rest of the optical range and, among others, $NH_2$ and $H_2O^+$ emissions, were covered using the 437+860 setting (ranging from 373 to 499 nm in the blue and from 660 to 1060 nm in the red). For both setups, we used a 0.44" slit, providing a resolving power of R~80000.

The basic data reduction was made using the ESO UVES pipeline in combination with IRAF routines. More details regarding data reduction procedures can be found in [4]

## 3. Data analysis and Results

As reported in [1], we detect strong emissions of $N_2^+$ and $CO^+$. In addition to those two ions, we report the clear detection of $CO_2^+$, fainter emissions of $CH^+$, CN, $C_2$, $C_3$, and a possible detection of CH. From those high-resolution spectra of C/2016 R2 (Pan-STARRS) we are thus able to measure the

$N_2^+/CO^+/CO_2^+$ ratios in the coma of the comet, and compare its $N_2^+/CO^+$ ratio to the ratio in other comets. The forbidden oxygen lines at 5577.339, 6300.304, and 6363.776 Å are detected, allowing us to measure the ratio between the green line and the red doublet. The so-called G/R ratio provides a way to determine the abundance of CO and $CO_2$ relative to $H_2O$ in the coma of comets. Such a measurement is particularly interesting in the case of C/2016 R2, which has strong $CO^+$ and $CO_2^+$ emissions, but no detected $H_2O^+$ emission.
We do not detect individual $^{14}N^{15}N^+$, and derive an upper limit on the $^{14}N/^{15}N$ isotopic ratio in the coma of comet C/2016 R2 (Pan-STARRS).
Finally, we also report the first detection of the [NI] lines at 5197.900 and 5200.256Å in the coma of a comet.

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## References

[1] Cochran, A. L. & McKay, A. J., Strong $CO^+$ and $N_2^+$ Emission in Comet C/2016 R2 (Pan-STARRS) ApJ, 854, L10, 2018
[2] Ivanova, O.V., Lukyanyk, I.V., Kiselev, N.N. et al.: Photometric and spectroscopic analysis of Comet 29P/Schwassmann-Wachmann 1 activity, PSS, 121, pp. 10-17, 2016
[3] Korsun, P. P., Rousselot, P., Kulyk, I. V., Afanasiev, V. L., & Ivanova, O. V. Distant activity of Comet C/2002 VQ94 (LINEAR): Optical spectrophotometric monitoring between 8.4 and 16.8 au from the Sun, Icarus, 232, 88, 2014
[4] Manfroid, J., Jehin, E., Hutsemékers, D., et al.: The CN isotopic ratios in comets, A&A, 503, pp. 613-624, 2009
[5] Rubin, M., Altwegg, K., Balsiger, H., et al., Molecular nitrogen in comet 67P/Churyumov-Gerasimenko indicates a low formation temperature, Science, 348, 232, 2015