

rates, and production rates and abundance ratios relative to simultaneously measured H<sub>2</sub>O for eight trace molecules in the coma: CO, H<sub>2</sub>CO, CH<sub>3</sub>OH, CH<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>2</sub>H<sub>6</sub>, HCN, and NH<sub>3</sub>. These trace molecules were depleted relative to their respective median abundances found among comets, excepting NH<sub>3</sub>, which was consistent with its median abundance. Most surprising were pronounced increases in abundance ratios for two trace volatiles between September 5 and 6, especially for C<sub>2</sub>H<sub>6</sub> but also for CH<sub>3</sub>OH. On September 5, C<sub>2</sub>H<sub>6</sub> was severely depleted, consistent with its lowest abundance yet measured for any comet. It also tracked the spatial profile of H<sub>2</sub>O, suggesting C<sub>2</sub>H<sub>6</sub> was associated with a polar ice phase dominating gas production. On September 6, C<sub>2</sub>H<sub>6</sub> was moderately depleted and was spatially distinct from H<sub>2</sub>O, suggesting both polar- and nonpolar-dominated ice phases contributed to the activity then. Our results are consistent with a non-homogeneous volatile composition for C/2013 V5. Possible implications will be discussed.

#### 210.14 Characterization of CO and H<sub>2</sub>O During the Outburst of C/2015 ER61 with iSHELL

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##### **Abstract**

On April 05, 2017, C/2015 ER61 was reported as undergoing an outburst with magnitude estimates between 7.4 and 6.5, up from a pre-outburst level of 8.4 mag. Observations from the TRAPPIST-South telescope showed that the gas production rates increased by a factor of 7 compared to observations made on 2017 March 31, and the dust mass-loss rate increased by at least a factor of 4. Prior to the outburst, C/2015 ER61 was already an intriguing target. Discovered by the Pan-STARRS1 telescope in March 2015, it has the most eccentric orbit and the fourth-largest aphelion of any known minor bodies in the Solar System. It was coming from the inner Oort cloud but appeared as an asteroidal object of magnitude of 20.7 upon discovery. By 2015 June, when 7.7 au from the Sun, a faint coma was detected for the first time by the Gemini telescope. C/2015 ER61 brightened significantly when it passed inside 6 au. We used iSHELL at the IRTF on UT 2017 April 05 ( $R_h = 1.18$  au) to obtain high resolution spectra of volatiles released immediately during the outburst. Here we report production rates for CO and H<sub>2</sub>O and compare the abundance ratios with those measured for other comets. Support for this work was obtained from NSF grants AST-1617015 and AST-1413736. The IRTF is operated by the University of Hawaii under contract NNH14CK55B with the National Aeronautics and Space Administration.

#### 210.15 A high resolution spectrum of comet C/2016 R2 (PanSTARRS) with the ESO VLT

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##### **Abstract**

The returning long period comet C/2016 R2 (PanSTARRS) was discovered on September 7, 2016 at 6.3 au from the Sun. While it was already showing a 20" coma at this large distance (Weryk and Wainscoat 2016), it is only in December 2017 that it was found that this comet had a very unusual composition. From radio observations the comet appeared to be very rich in CO and very poor in HCN (Wierzbach and Womack 2018) and its optical spectrum was dominated by CO<sup>+</sup> and more surprisingly N<sub>2</sub><sup>+</sup> emission bands (Cochran and McKay 2018), while most of the emission bands usually detected in the optical spectrum of comets were not detected.

In order to investigate in detail its coma in the optical, we obtained a total of 6 hours of Director Discretionary Time on C/2016 R2 with UVES, the high resolution optical spectrograph of the ESO Very Large Telescope, between February 11 and 16, 2018. We used two different settings to optimally cover the whole optical spectrum (326-1060 nm) with a resolving power of 80.000. We report on those observations.

We detect strong emissions of the ions  $\text{CO}^+$  and  $\text{N}_2^+$ , and also several  $\text{CO}_2^+$  bands, but no  $\text{H}_2\text{O}^+$ . We detect emission lines of the radicals CN,  $\text{C}_2$  and  $\text{C}_3$  but they are very weak. We computed from these spectra the  $\text{N}_2^+ / \text{CO}^+ / \text{CO}_2^+$  ratios in the coma of the comet which put some constraints on the comet formation models, and compared those values to other comets. The forbidden oxygen [OI] lines are detected, allowing to measure the ratio between the green line and the red doublet which provides a way to determine the abundance of CO and  $\text{CO}_2$  relative to  $\text{H}_2\text{O}$ . For the first time we report the detection of the nitrogen [NI] forbidden doublet at 5197.9 and 5200.2 Å in the coma of a comet, confirming the high abundance of nitrogen in this comet. Interestingly we also detect a line at 9850 Å which could be one of the carbon [CI] forbidden lines but we do not detect the other line of the doublet at 9823 Å. Because of the strong  $\text{N}_2^+$  emissions, it was also a unique opportunity to measure the  $^{14}\text{N}/^{15}\text{N}$  isotopic ratio directly in  $\text{N}_2$ , the main nitrogen reservoir in the solar nebula.