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VLT multi-instrument observations of comet 46P/Wirtanen

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Abstract

We present observations of the Jupiter family comet 46P/Wirtanen performed at the ESO/VLT in December 2018 with three different instruments: the high-resolution spectrographs UVES and ESPRESSO, and the MUSE integral field spectrograph. Combining those observations, we investigate the coma composition and main activity drivers of 46P, as well as species parentage and jets in its coma.

1. Introduction

Comet 46P/Wirtanen (hereafter 46P) made a very close approach to Earth in December 2018, at only 0.08 au. Because of its close passage and proximity to perihelion, the comet was very bright, which is particularly rare for a Jupiter Family comet. It also provided a unique opportunity to study the very inner part of the coma, difficult to reach with ground-based observatories for most comets. For these reasons, 46P was the target of numerous ground and space-based observatories across the world (HST, IRTF, ALMA, ...). As a part of this large campaign, we observed 46P with three different instruments at the ESO/VLT: ESPRESSO, UVES, and MUSE.

2. Observations

2.1 ESPRESSO

ESPRESSO is a high-resolution spectrograph recently installed at the VLT, able to reach an extremely high spectral resolution (maximum resolving power ~190000) while simultaneously covering the wavelength range between 380 and 788nm. ESPRESSO, in its highest resolution mode, has two fibers of 0.5", the first one centered on the target, and the second one 7" away. The resolution and the stability of ESPRESSO allow us to measure the intrinsic width of numerous cometary lines and detect very small shifts in their position. We observed 46P with ESPRESSO for a total of 12 hours on December 9 and 10, 2018. Those are the first observations of a comet with the new ESPRESSO instrument and we show the new possibilities it opens for the study of comets.

2.2 UVES

UVES is a high-resolution echelle spectrograph installed at the UT2 telescope of the VLT. UVES has a lower spectral resolution than ESPRESSO (resolving power ~80000) but covers a larger wavelength range. We were granted 2 hours of observations with UVES on the night of December 9 2018, simultaneously to the ESPRESSO observations. With only 2 settings (DIC1 348+580 and DIC2 437+860), we covered the full optical range between 305nm and 1060nm.

2.3 MUSE

MUSE is a multi-unit integral field spectrograph mounted on the UT4 telescope of the VLT. MUSE has a large field of view of 1'x1', covered with a spatial resolution of 0.2", which makes it an ideal instrument to study extended sources. It benefits from a large wavelength coverage, from 480 to 930 nm, and a resolving power of about 3000. We gathered a total of 4 hours of observations of 46P with MUSE, divided in four 1h blocks executed between October and mid-December 2018.

3. Results

Combining the observations from those three instruments (as well as simultaneous observations performed with the TRAPPIST telescopes), we aim at getting a more comprehensive view of 46P's coma composition and dynamics. Using high resolution spectra obtained with both UVES and ESPRESSO we put limits on the $^{13}C/^{13}C$, $^{16}O/^{18}O$, and $^{14}N/^{15}N$ isotopic ratios.

Thanks to the high spectral resolution of ESPRESSO, we can resolve the forbidden oxygen lines at 557.7, 630.0, and 636.4nm from the telluric lines in spite of the low geocentric velocity of the comet at the time of the observations (see Fig. 1). By measuring the ratio between the green (557.7 nm) and the red oxygen lines (630.0, and 636.4nm) at two different positions in the coma, we estimate the contribution of CO and CO_2 relative to H_2O.

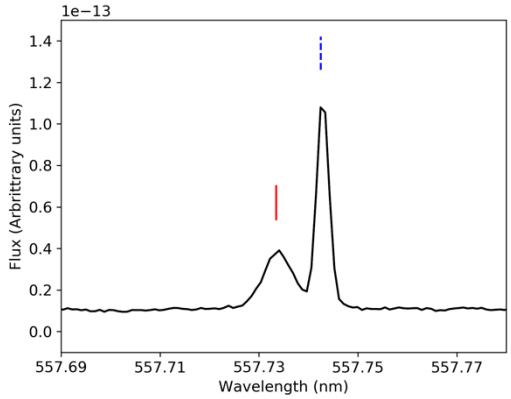

Figure 1: ESPRESSO spectrum of 46P centered on the green forbidden oxygen [OI] line at 557.73 nm. The cometary oxygen line is identified by the red tick mark while the dashed blue tick mark indicates the corresponding telluric line. The y-axis is in arbitrary units.

From the ESPRESSO spectra obtained at ultra-high resolution and with a very stable wavelength calibration, we can also measure the intrinsic width of the lines and detect very small variations of their positions. This allows us to study and compare the dynamics of various gas species (CN, C_2, C_3, NH2) in the coma.

Finally, observations of 46P with the MUSE IFU allow us to produce maps of several gas species and the dust in the coma of the comet. The comparison of the spatial distribution of the gas and the dust in those maps provides a way to characterize the release mechanisms of several species (CN, C_2, and NH_2) at different points of the orbit and reach a better understanding of the species parentage in the coma of comets.

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