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Thesys title:

HIRES/EELT Science Case for astrobiological relevant targets: comets.

Tutors:

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General Scientific background: Comets as hints of origin of Earth's oceans.

Life on Earth, as we know it, is based on liquid water, thus the search for water in non-terrestrial environments is one of the main goals of astrobiology. Origin of Earth's oceans is still not clear.
Water is the most abundant constituent of cometary ices, so the natural question that scientists consider is: Did comets deliver water to Earth? Water production rate is used to quantify cometary activity. Moreover, from investigations of the isotopic ratio D/H in various bodies of the solar system, the origin of terrestrial water was attributed, for the most part, to small bodies, with particular attention to Jupiter family comets. Indeed the estimated value of D/H in the 103P/Hartley 2 Jupiter family comet is about 1.61×10^{-4} in agreement with the VSMOW= 1.5576×10^{-4} (Hartogh et al. 2011, van Dishoeck et al. 2014), however, even lower values of D/H are expected among Jupiter Family Comets, and Oort cloud comets exhibit a range that approaches VSMOW (Mumma and Charnley 2011). The detection of tracers of water and its isotopologues is important for constraining the water production rate in a comet and the origin of water on Earth.
Ground-based observations initially emphasized detection of H_2O through emission lines of the (111-100) vibrational band near 2 μm with single lines first detected in C/1991 T2 Shoemaker-Levy and 6P/dArrest. Application to C/1996 B2 Hyakutake detected 13 lines with $Q(HO)=1.7\times10^{29}$ s^{-1}

(Mumma et al. 1996). With Hale-Bopp and later comets, attention shifted to H_2O emissions in the >2.9 μm region, for simultaneous detection with other volatile species.

Specific work:
Observations with GIANO/TNG

GIANO is the new high resolution spectrograph mounted on TNG telescope in La Palma, Canary Islands, ES. GIANO covers more or less the same spectral range (0.9-2.5) μm as HIRES spectrograph will cover (0.3-2.5)μm, so working on GIANO would be essential for my PhD project, to plan the best use of HIRES.
During last part of technical test on the instrument, in Feb 2015, I had the possibility to collect the first scientific images with GIANO, testing the power of the instrument, targeting the comet C/2014 Q2 (Lovejoy). 52 water emission lines have been detected, in 8 ro-vibrational bands, across the echellogram near 1.4 μm and near 2 μm (Faggi et al. 2016, ApJ submitted). We derived a water production rate of $Q(H_2O)= (3.11 \pm 0.14)x10^{29}s^{-1}$ after comparing the calibrated line fluxes with the full non-resonance cascade fluorescence model for H_2O and HDO (Villanueva et al. 2012). We also detected emission from the red-system of CN, and many other emission lines whose precursors are now being identified. In Feb 2016 we observed comet C/2013 X1 (Panstarrs), backup target of the scheduled and unfortunately faint comet C/2013 US10 (Catalina). Comet C/2013 X1 (Panstarrs) revealed itself an interesting target even if it was not at the maximum of its activity. We detected water near 1.46 μm, indeed.
The main aim is to investigate the potential of the new high resolution IR spectrograph GIANO, in order to develop a science case for future new high resolution IR spectroscopy on 39-m class telescopes, like E-ELT. The observations performed on comets can allow me to understand the power of a new generation instrument like HIRES mounted on E-ELT, establishing the comprehension of the observing limits that we will meet. We the advent of such powerful instruments it wouldi be possible to find an answer to the puzzling origin of Earth's oceans.

References:

Faggi et al., 2016, ApJ. Detailed analysis of near IR water (H2O) emission in comet C/2014 Q2 Lovejoy with the GIANO spectrograph. (submitted)

Hartogh, P. et al., 2011. Ocean-like water in the Jupiter-family comet 103P/Hartley 2. *Nature*, 478(7368), pp.218–220.

Mumma et al., 1996, Detection of Abundant Ethane and Methane, along with Carbon Monoxide and Water, in Comet C/1996 B2 Hyakutake: Evidence for Interstellar Ice, Science 272, No. 5266: 1310-1314.

Mumma, M. J. and S. B. Charnley, 2011, The Chemical Composition of Comets: Emerging Taxonomies and Natal Heritage,Ann. Rev. Astron. Astrophys. 49:471-524.

van Dishoeck et al., 2014 arXiv:1401.8103 [astro-ph.GA]

Villanueva et al., 2012, Water in planetary and cometary atmospheres: H2O/HDO transmittance and fluorescence models. Journal of Quantitative Spectroscopy & Radiative Transfer 113 (2012) 202-220.