Activities and origins of interstellar comet 2I/Borisov

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We will present the results of coordinated observations of 2I/Borisov with the Neil Gehrels-Swift observatory (Swift) and Hubble Space Telescope (HST), which allowed us to provide the first glimpse into the ice content and chemical composition of the protoplanetary disk of another star. Comets are condensed samples of the gas, ice and dust that were in a star’s protoplanetary disk during the formation of its planets, and inform our understanding on how chemical compositions and abundances vary with distance from the central star. Their orbital migration distributes volatiles [1], organic material and prebiotic chemicals around their host system [2]. In our Solar System, hundreds of comets have been observed remotely, and a few have been studied up close by space missions [3]. Similarly, interstellar comets offer a glimpse into the building blocks, formation, and evolution of other planetary systems. However, knowledge of extrasolar comets has been limited to what could be gleaned from distant, unresolved observations of cometary regions around other stars. 2I/Borisov, discovered in Aug. 2019, is the first notably active interstellar comet discovered in our Solar System [4].

We used the UltraViolet Optical Telescope (UVOT) of Swift to determine 2I/Borisov’s water production rates and dust content surrounding the nucleus at six epochs spaced before and after perihelion on Dec. 8.55, 2019 UTC (-2.56AU to 2.54AU) [5]. Water production rates increased steadily before perihelion at a rate of increase quicker than that of most dynamically new comets but slower than most Jupiter-family comets. After perihelion, the water production rate decreased much more rapidly than that of all previously observed comets. We used a sublimation model to constrain the active area and minimum radius of the nucleus, and found that a significant fraction of the surface of Borisov is active.

We also used Cosmic Origins Spectrograph (COS) on the HST during four epochs around the perihelion and clearly detected the emissions of several bands of the CO Fourth Positive system, which we used to derive CO production rates [6]. Comparing these with the water production rates
determined by Swift, we found that after perihelion, the coma of 2I/Borisov contains substantially more CO than H2O gas. Our abundances were more than three times higher than previously measured for any comet in the inner (<2.5 au) Solar System [3]. The derived high abundance ratio of CO/H2O and high elemental abundance of carbon relative to oxygen firmly sets 2I/Borisov apart from solar system comets, and suggest that the physical and chemical environment were Borisov was formed are substantially different from those in our solar system [6, 7].

Fig. 1 Volatile production rates as a function of time relative to perihelion [6]. The production rates of CO measured with HST/COS (this work) and the water production rate measured by Swift (based on OH, open circles; 5) and the Very Large Telescope/UVES (based on OH, 8), and at the Apache Point Observatory (based on [OI], 9). Arrows indicate 3-σ upper limits, and error bars indicate 1-σ stochastic uncertainties. The grey line indicates the temporal trend of water production rates used to derive the elemental composition.

References:

