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Observing the infant bow shock at comet 67P/Churyumov-Gerasimenko

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The bow shock is the first boundary the solar wind encounters as it approaches planets or comets. For a comet the bow shock develops gradually as it approaches the Sun and outgassing from the nucleus increases. Fully developed cometary bow shocks were observed in the 1980s and 90s when several spacecraft flew by comets 1P/Halley, 26P/Grigg–Skjellerup, and 21P/Giacobini–Zinner close to perihelion. The Rosetta spacecraft followed comet 67P/Churyumov-Gerasimenko (67P) for 2 years, but it did not observe the fully developed bow shock, since the spacecraft did not venture far enough upstream while the comet was at perihelion. It was long thought that no bow shock was observed at all at comet 67P, but that has now changed.

By being present at the comet during its journey toward the Sun, through perihelion, and back outward again, the Rosetta spacecraft was able to observe the very formation of the bow shock (*H. Gunell, C. Goetz, et al., A& A, vol. 619, L2, 2018, doi:10.1051/0004-6361/201834225*). The spacecraft crossed the newly formed bow shock several times during two periods: a few months before and after perihelion, corresponding to heliocentric distances in the approximate range of $(2.0 - 2.5)$ AU.

In this paper, we present data obtained by instruments of the Rosetta Plasma Consortium at comet 67P. Specifically, we present two cases: the first from 7 March 2015, when the comet was at 2.2 AU from the Sun on its inbound journey, and the second from 24 February 2016, at 2.4 AU going away from the Sun. This bow shock under formation has been named *the infant bow shock* to distinguish it from fully developed bow shocks that regularly are observed at planets. During the infant bow shock encounters, Rosetta observed an increase in magnetic field magnitude and oscillation amplitude, electron and proton heating at the shock, and the diminution of the solar wind further downstream.

Quasi-neutral hybrid simulations of the comet–solar wind interaction have shown that the bow shock is asymmetric in this stage of its development, and that it is relatively wide compared to the distance to the nucleus. We compare simulated magnetic fields and ion spectra to the Rosetta observations of the same quantities.

In summary, Rosetta observed a cometary bow shock in its infancy – a stage in its development not previously discovered at comets and planets.