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Anomalous deformation of the Earth's bow shock in the lunar wake: Joint observations by Chang'E-1 and SELENE

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Along its orbital motion around the Earth, the Moon crosses the bow shock (BS) at the dusk and dawn flanks. Meanwhile, behind of the Moon along the solar wind (SW) flow forms a tenuous region called lunar wake, because the SW plasma is obstructed by the Moon. Because of the low density in the wake region, Alfvén Mach number ($M_{\rm a}$) should be low and thus we expect that the portion of the BS surface touched by the lunar wake will be affected significantly.

Here we report, with simultaneous observations by Chang'E-1 and SELENE, that the Earth's BS surface is locally deformed in the lunar wake. Despite the quasi-perpendicular shock configuration encountered at dusk-flank under the Parker-spiral magnetic field, no clear shock surface can be found in the lunar wake, while instead gradual transition of the magnetic field from the upstream to the downstream value was found for a several-minute interval. This finding suggests that the 'magnetic ramp' is highly broadened in the wake where the flow can be sub-Alfvénic due to the lowest density and that a fast-mode shock is no longer maintained there.

On the other hand, the Earth's BS survived at only 100 km altitude on the lunar dayside. It is worth noting that the 100 km altitude of SELENE from the lunar surface is smaller than both the observed ramp thickness ($\sim$150–180 km) and the convected ion gyroradius ($\sim$250 km/s). The observation at the 100 km altitude shows that the fast-mode shock is maintained even when the width of the downstream region was smaller than the convected ion gyroradius that is a typical scale length of a quasi-perpendicular shock.

Our results suggest that the Moon is not so large to eliminate the BS at 100 km altitude on the dayside, while the magnetic field associated with the shock structure is drastically affected in the lunar wake.