# Foreshock cavity upstream of the Moon

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Lunar crustal fields are extensively spread over the entire lunar surface with various field intensities, but they are mostly clustered on the southern hemisphere of the lunar far side. Observations reveal that on average ~10% of the incident solar wind proton flux to the lunar crustal fields is reflected in charged form. When the interplanetary magnetic field (IMF) is (quasi)parallel to the solar wind flow and is connected to the lunar crustal fields, a large fraction of reflected protons move upstream of the Moon, interact with incoming solar wind plasma, and build-up a large cavity upstream of the Moon. We present an event captured by the ARTEMIS probes that demonstrates such phenomena. The plasma cavity is surrounded by a slightly enhanced magnetic field, while the strength of the fields are considerably reduced inside the cavity. The plasma is heated in the center of the cavity, however, ARTEMIS does not observe significant plasma deflection or deceleration. Events with similar characteristics have been observed in planetary foreshocks (e.g., the Earth, Venus, and Mars), known as Hot Flow Anomalies (HFAs). However, a distinct difference between the foreshock cavity observed by ARTEMIS upstream of the Moon compared to those of the HFAs is the lack of any magnetic discontinuity. In order to investigate the physical drivers of this event, we have used a three-dimenstional hybrid model of plasma (particle ions, charge neutralizing fluid electrons) and an observed map of reflected protons from lunar crustal magnetic fields. We apply the undisturbed plasma parameters observed by ARTEMIS into our model and compare our simulations with ARTEMIS observations. Our model-data comparison suggests that the lunar foreshock cavity is formed due to proton reflection from lunar crustal fields. When the IMF is parallel to the solar wind, reflected protons from lunar crustal fields move upstream and build up ion-ion plasma instabilities which form a large cavity with similar charateristics to those of an HFA.