Possible mechanisms of an ESW excitation in the lunar wake boundary

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The electrostatic solitary wave (ESW) is one of the plasma waves commonly seen in space, and it is observed as broadband electrostatic noises (BENs) in frequency-time spectrograms. It has been pointed out that the ESWs are generated by a bi-stream electron beam instability or a bump-on-tail instability driven by an electron beam in a warm thermal plasma. In the last decade, Kaguya (SELENE) spacecraft in orbit around the Moon detected ESWs in the wake boundary, but its generation mechanism has not been understood yet. Here we analyze an ESW event in the wake boundary reported by Hashimoto et al. (2010), showing velocity distribution functions of electrons. In the event, the Kaguya spacecraft at 100 km altitude is magnetically connected to the lunar night-side surface, and detects upward-travelling field aligned electron beams (at 100-150 eV). The upward electron beams form a bi-stream distribution function with the solar wind strahl-electrons going down toward the lunar night-side surface along the interplanetary magnetic field. A statistical study also shows dependence of BENs in the wake boundary on the downward electron distribution and upward electron beams. We discuss a possibility of ESW generation by a bi-stream instability by the upward lunar electrons and the downward solar-wind strahl-electrons.