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Use of Lagrange L2 point for magnetospheric and planetary evolution studies

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Recent in-situ studies suggest that ion and neutral escapes have substantially affected the evolution of the atmosphere and life. To examine this problem, we need a dedicated mission. One example is ESCAPE (http://cluster.irap.omp.eu/public/ESCAPE/ESCAPE_M5_Proposal_V1.1.pdf) targeting comprehensive understanding of both ion escape and neutral escape, with as much cost as 400 Meur.

Size and cost of the mission can be reduced significantly by limiting our target, e.g., to the total ion escape rate, during very active solar/geomagnetic conditions, which are the most relevant from the atmospheric evolution viewpoint for the present Earth. By limiting measurements to ions, the Sun-Earth Lagrange L2 point becomes an ideal place because a semi-stable Lissajous/Halo orbit around L2 rather than orbiting the Earth allows to quickly explore the 2D cross-section of the tail magnetosphere, through which all escaping ions will flow after picked up by the solar wind.

One advantage of the Sun-Earth L2 is that we expect good piggyback opportunities, because L2 is a favorite place for large space observatories (e.g., ESA's Herschel, Gaia, and Euclid) that require relatively large launchers. The resulting large piggyback capabilities at L2 are not useful for Earth observation or commercial purposes, allowing extra science missions as piggyback. In fact, ESA recently announced a science mission opportunity of nearly one ton starting from L2 as piggyback of PLATO or ARIEL missions.

The size of a piggyback L2 mission for ion escape measurements can range from a formation of one mother plus two daughter spacecraft (Far Tail Explore: FATE) down to a single cubesat mission. The cubesat/daughter is equipped with two ion instruments (MCP-type for 0.1-20 keV and SSD-type for 15-85 keV that can cover picked-up O^+ up to 1000 km/s) and minimum additional supportive payload (magnetometer and/or Langmuir probe), costing less than 10 Meur including instrument and launch. In the FATE mission (http://www2.irf.se/%7Eyamau/future/f1/Fate_phase1_final.pdf) that we proposed for ESA's A/O, the mother spacecraft has more complete particle and supportive packages.

With FATE instrumentation, it is possible (1) to obtain the total ion escape (flux, active cross-section, and composition) from the Earth and its variability at the ultimate downstream, (2) to identify the relative importance of the different ion escape routes and mixing of different plasmas far downstream, (3) to monitor interplanetary shocks / solar energetic particles (SEP) at the Earth and L2 for more accurate space weather warning, (4) to study fine-scale magnetospheric boundary far downstream where all boundary-related instabilities are well developed including folding including transient interactions with SEP.