JEM-EUSO and its pathfinder Mini-EUSO to observe meteors from the International Space Station

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Abstract

Since several years an International Collaboration involving several research institutes located in 16 countries of 4 different continents (Europe, Asia, America and Africa) has been working on the development of the JEM-EUSO mission to be carried out from the International Space Station (ISS). The project has evolved with time, and it includes now also a smaller, pilot mission, named Mini-EUSO, supposed to fly in advance before the proposed main mission. The main goal of JEM-EUSO is the detection of Ultra High Energy Cosmic Rays (UHECR, $5 \times 10^{19} - 10^{21}$ eV), by means of a dedicated refractive telescope (2.5 m of aperture) equipped with an UV detector on its focal plane, covering a wavelength range between 290 and 430 nm, positioned in one of the modules of the ISS in such a way as to carry out Nadir observations from an height of about 400 km above sea level on a full field ov view (FOV) of $\sim 60°$. In this way, the instrument will detect the secondary light emissions induced by cosmic rays in the atmosphere (fluorescence light and Cerenkov). This mission design also makes it possible the detection of a variety of transient luminous events in the atmosphere, including meteor phenomena.

Mini-EUSO, as a pathfinder mission for JEM-EUSO, will use the same technologies of JEM-EUSO but with smaller lenses (25 cm diameter), a coarser spatial resolution (5 km instead of 500 m) and smaller FOV $\sim 40°$. Mini-EUSO, a currently approved project of ASI and ROSCOSMOS, will be located inside the ISS, looking in the Nadir direction from the Russian Service Module UV transparent window.

Our preliminary analysis shows that JEM-EUSO should be able to detect meteors, in favourable conditions of dark background, down to magnitudes between 5 and 6, or possibly even fainter in the best possible conditions. Taking advantage of its large FOV and high detection rate, JEM-EUSO should be able to record a statistically significant flux of meteors, including both sporadic ones, and events produced by different meteor streams. Unaffected by adverse weather conditions, which limit the effectiveness of ground-based meteor observation networks, JEM-EUSO can also become a very important facility for the detection of bright meteors and fireballs, as these events can be detected even during periods of very high sky background. Therefore, monitoring of bright events will always be active, nicely complementing current ground-based activities like the French FRIPON program, whereas the detection of faint meteors requires more optimal observing conditions. In the case of bright events, moreover, exhibiting a much longer signal persistence with respect to faint meteors, our preliminary simulations show that it should be possible to exploit the movement of the ISS itself and derive at least a rough 3D reconstruction of the meteor trajectory. This would allow the position and velocity vectors to be computed instead of a simple 2D projection of the motion.

It is interesting to note that the observing strategy developed to detect meteors may also be applied to the detection of nuclearites, exotic particles whose existence has been suggested by some theoretical investigations. They are expected to move at higher velocities than meteoroids, and to exhibit a wider range of possible trajectories (including particles moving toward the zenith after crossing the Earth), but still at speeds that can be considered slow for JEM-EUSO. The possible detection of nuclearites greatly enhances the scientific rationale behind the JEM-EUSO mission. Currently, since the approval of the pilot Mini-EUSO, we are carrying out simulations aimed at assessing its performance for meteor studies.