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Status of the JEM-EUSO Collaboration: Ground, Balloon, and Space-Based Observations of UHECRs and Related Phenomena

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The JEM-EUSO (Joint Exploratory Missions for Extreme Universe Space Observatory) collaboration is an international initiative studying ultra-high-energy cosmic rays (UHECRs) and related phenomena. These particles, with energies exceeding 10^{20} eV, provide insights into extreme astrophysical processes but remain challenging to detect due to their low flux.

At the heart of JEM-EUSO's technology is an ultra-fast, highly sensitive UV camera capable of detecting extensive air showers (EAS) in the atmosphere with exceptional spatial and temporal resolution. This innovative approach enables detailed studies of fluorescence and Cherenkov light from cosmic ray interactions.

The collaboration employs a multi-platform strategy. Ground-based experiments like EUSO-TA have calibrated detection systems and validated models. Balloon-borne missions, such as EUSO-Balloon and EUSO-SPB1/SPB2, have demonstrated large-scale observations from the stratosphere and tested advanced technologies. Space-based missions, particularly Mini-EUSO on the ISS, have provided valuable data on UV backgrounds, transient luminous events, and meteoroids. While Mini-EUSO's small aperture limits its ability to detect UHECRs, it demonstrates the potential for future space-based detection.

Future efforts include the POEMMA space mission, designed for stereoscopic observations of UHECRs and multi-messenger phenomena, and the PBR (POEMMA Ballon with Radio) experiment, integrating radio detection and scheduled to fly in 2027. Associated experiments also explore meteoroids, nuclearites, and strange quark matter, broadening the scientific scope.

This presentation will summarize the progress of the JEM-EUSO collaboration, highlighting achievements across all platforms, future plans, and the significant contribution of the Polish team to scientific results.

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