MATFYZ CONNECTIONS

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Analysis of the spaceweathering effect on the surface of satellites and space debris

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Space weathering impacts all objects exposed to the space environment, including artificial satellites and space debris. Exposure to high-energy solar particles, micrometeoroids, and atmospheric particles degrades surface materials through oxidation, erosion, and paint peeling, producing wavelength-dependent changes detectable with observations in Johnson-Cousins photometric bands.

These effects were investigated through two observational campaigns targeting artificial space objects. The short-term campaign monitored recently launched CZ-3B rocket upper stages in geostationary transfer orbits over the course of eight months, while the long-term campaign focused on active GEO satellites annually over four years. The two groups differ in both material composition (painted metal vs. multi-layer insulation) and orbital environment.

Results show two distinct color index trends: GEO satellites exhibit darkening and spectral reddening consistent with the aging of multilayer insulation materials (e.g., Kapton, Mylar), whereas CZ-3B upper stages show brightening and spectral bluing, attributed to white paint flaking off and revealing the highly reflective metal surface underneath, accelerated by interactions with atomic oxygen. Differences between the two populations can be attributed to variations in material type, exposure duration, and orbital altitude.

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