Origins of dust in JWST-observed primeval galaxies at z~7

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We investigate a sample of star-forming galaxies at z∼7 observed with the James Webb Space Telescope (JWST), focusing on the diversity of their rest-frame ultraviolet spectral properties and, in particular, on the presence of the 2175 Å dust absorption feature. While only a subset of these galaxies exhibits a clear UV bump, its detection provides evidence for the presence of small carbonaceous grains and points to rapid enrichment of the interstellar medium (ISM) at early cosmic times. The aim of this work is to explore the physical conditions and dust production pathways responsible for the emergence of dust grains within the first billion years of cosmic history.

To this end, we analyze galaxies extracted from cosmological IllustrisTNG simulations, post-processed with dust evolution models and radiative transfer calculations. We compare these models with JWST rest-frame UV and optical spectra, and with Atacama Large Millimeter Array (ALMA) observations when available. Our models reproduce several continuum and emission-line diagnostics, including UV slopes, Balmer decrements, dust continuum emission, and [CII] 158μm line fluxes.

We find that the observed dust content, including small carbonaceous grains, can be explained either by efficient dust growth in the ISM combined with low dust condensation efficiencies in Type II supernova ejecta, or by highly efficient dust production in supernovae with limited ISM grain growth. In contrast, dust production dominated solely by asymptotic giant branch (AGB) stars appears insufficient to explain both the observed UV bump and the overall dust content of galaxies at these early epochs.