Uncovering the Origins of the 2175Å UV Bump at High Redshift

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UF Astronomy

Q: Why do we find the UV bump at high redshift?

- The UV bump resides primarily in metal-rich galaxies in the local universe
- At high redshift we expect galaxies to be metal-poor on average
- It is therefore puzzling as to why we see this feature in galaxies at z~7, within a Gyr of the Big Bang (prior to when we would expect AGB-driven dust production to occur)

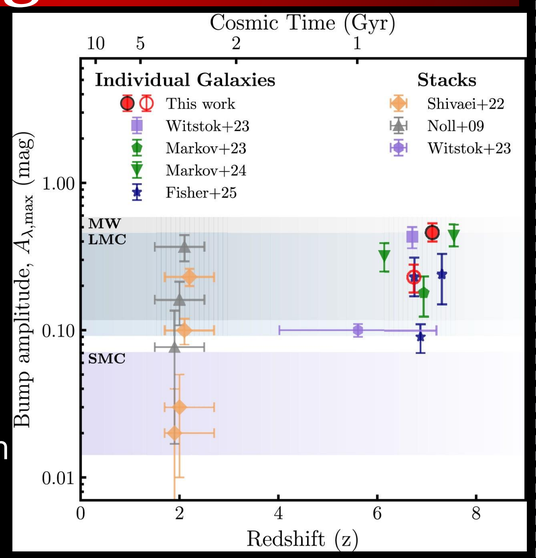
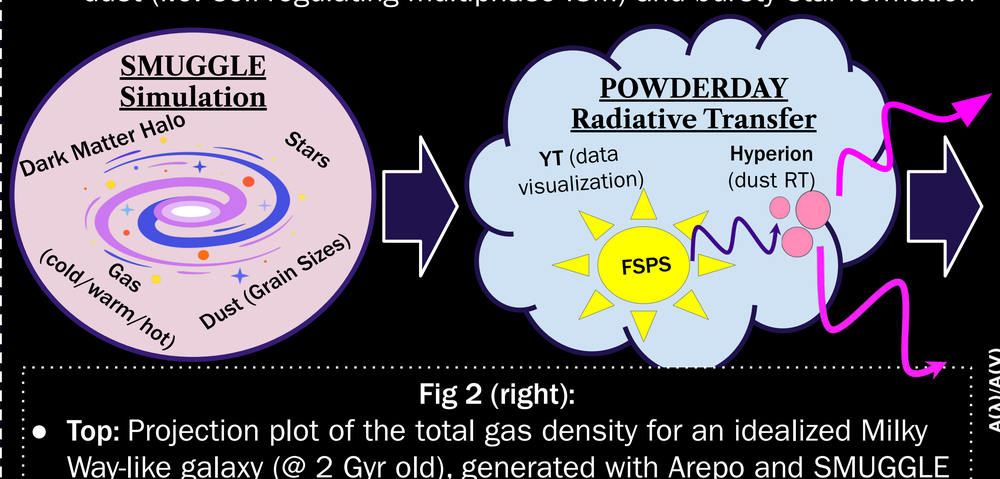
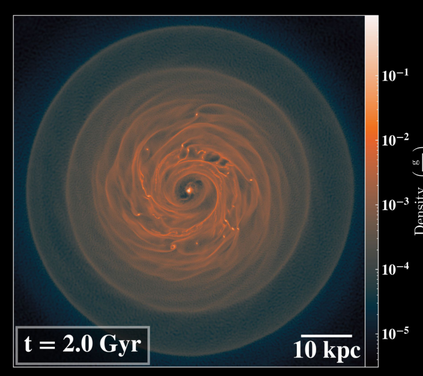


Fig 1 (above): Observations of 2175Å UV bump strength as a function of redshift (z)

Goal: Use cosmological galaxy formation simulations to investigate the nature and origins of the UV bump at high z

- **Method:** employ the Arepo code with the SMUGGLE galaxy formation model (SMUGGLE = Stars and MUltiphase Gas in GaLaxiEs)
- SMUGGLE includes a novel multi-size, multi-composition model for dust (i.e. self-regulating multiphase ISM) and bursty star formation





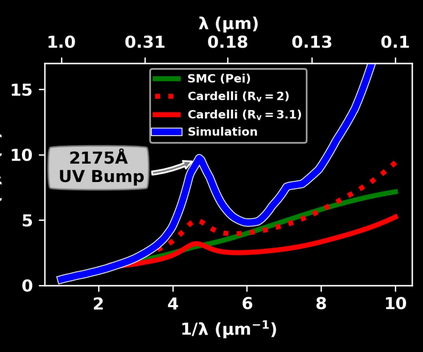
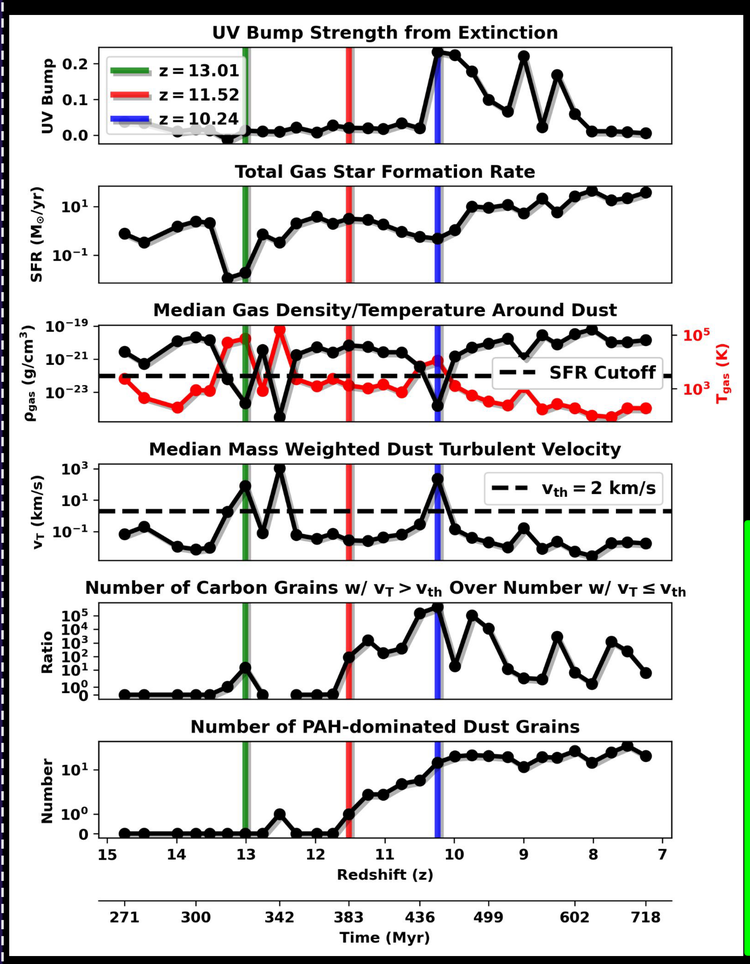


Fig 2 (right):

- **Top:** Projection plot of the total gas density for an idealized Milky Way-like galaxy (@ 2 Gyr old), generated with Arepo and SMUGGLE
- **Bottom:** Extinction plot for our simulated galaxy is shown in blue, with a grey arrow pointing to the 2175Å UV bump

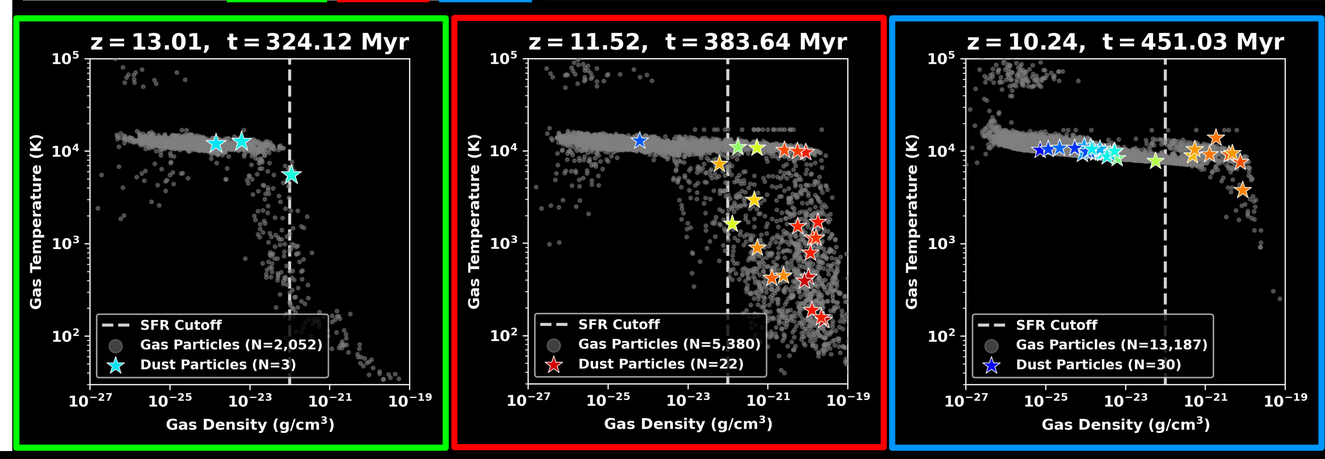


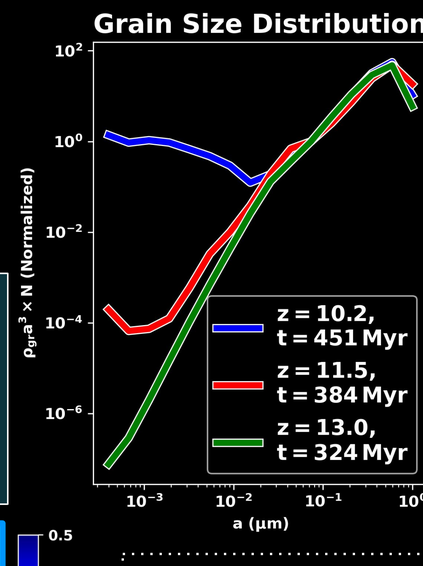
Analysis of a Single Galaxy's Evolution

Fig 3 (left): shows how the UV bump strength (from extinction) for a galaxy will co-evolve with fundamental galaxy properties

Redshift (z)	13.0	11.5	10.2
Density	↓	↑	↓
Temperature	↑	↓	↑
Star Formation	✗	✓	✓
Shattering	✓	✗	✓

At early times (z~13; green line), dust grains are hot, turbulent, and prone to shattering. Later, by z~11.5 (red line), the dust has cooled enough for stars to begin forming. The UV bump in extinction emerges only when these conditions coincide, around z~10.2 (blue line)





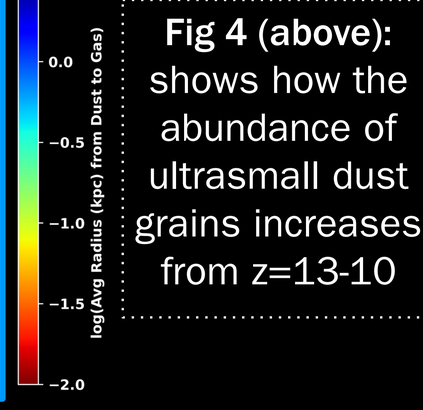


Fig 4 (above): shows how the abundance of ultrasmall dust grains increases from z=13-10

Conclusions and Future Work

- **Fig 5 (right):** By combining the dust properties of over 20 galaxies at all points in time, we can get a picture for how the trends identified above will behave globally
- We find that while high densities are required to form stars, high temperatures (low densities) are instead necessary to trigger shattering and thus create ultra-small grains and a UV bump in extinction
- **Next steps** include expanding analysis from extinction → attenuation, and adding more galaxies for statistics

References

- Ormerod et al., 2025
- Narayanan et al., 2023
- Witsok et al., 2023
- Markov et al., 2025
- Grant Donnelly

Taken together, this implies that the introduction of a UV bump in extinction requires both a substantial population of dust particles near star-forming regions, *as well* as a large population of dust that has been pushed away by stellar feedback to regions of low density (high temperature) in order to enable shattering and create small grains