Spontaneous Reheating during Crystallization of Stardust: Resolution of an Interstellar Medium Paradox

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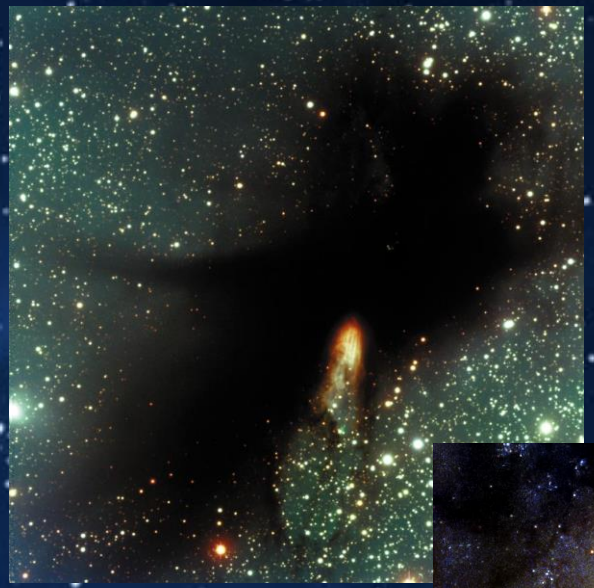
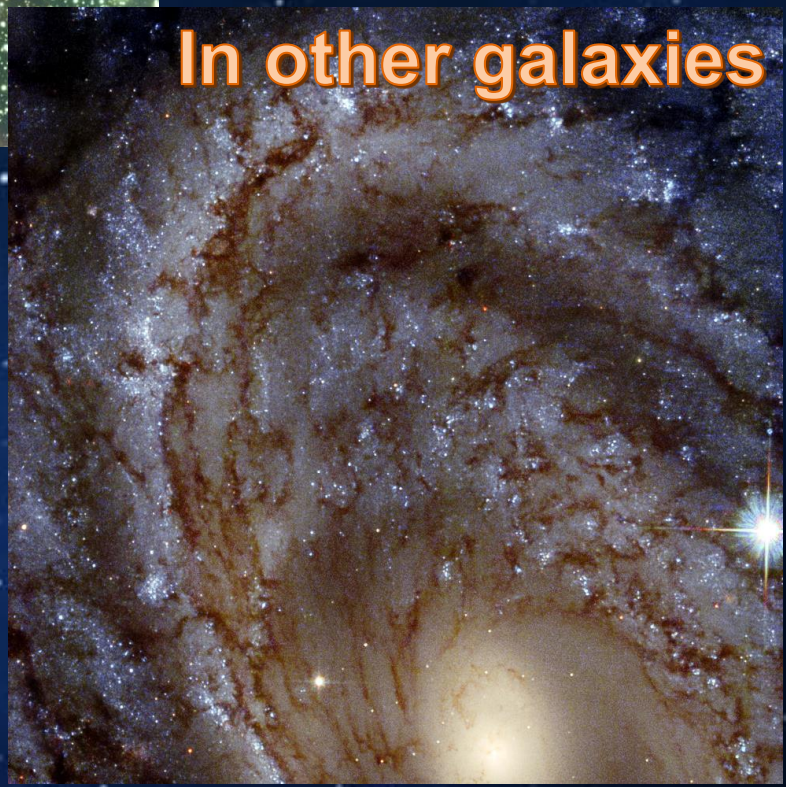
Dust in space is everywhere

Star birth

In between stars

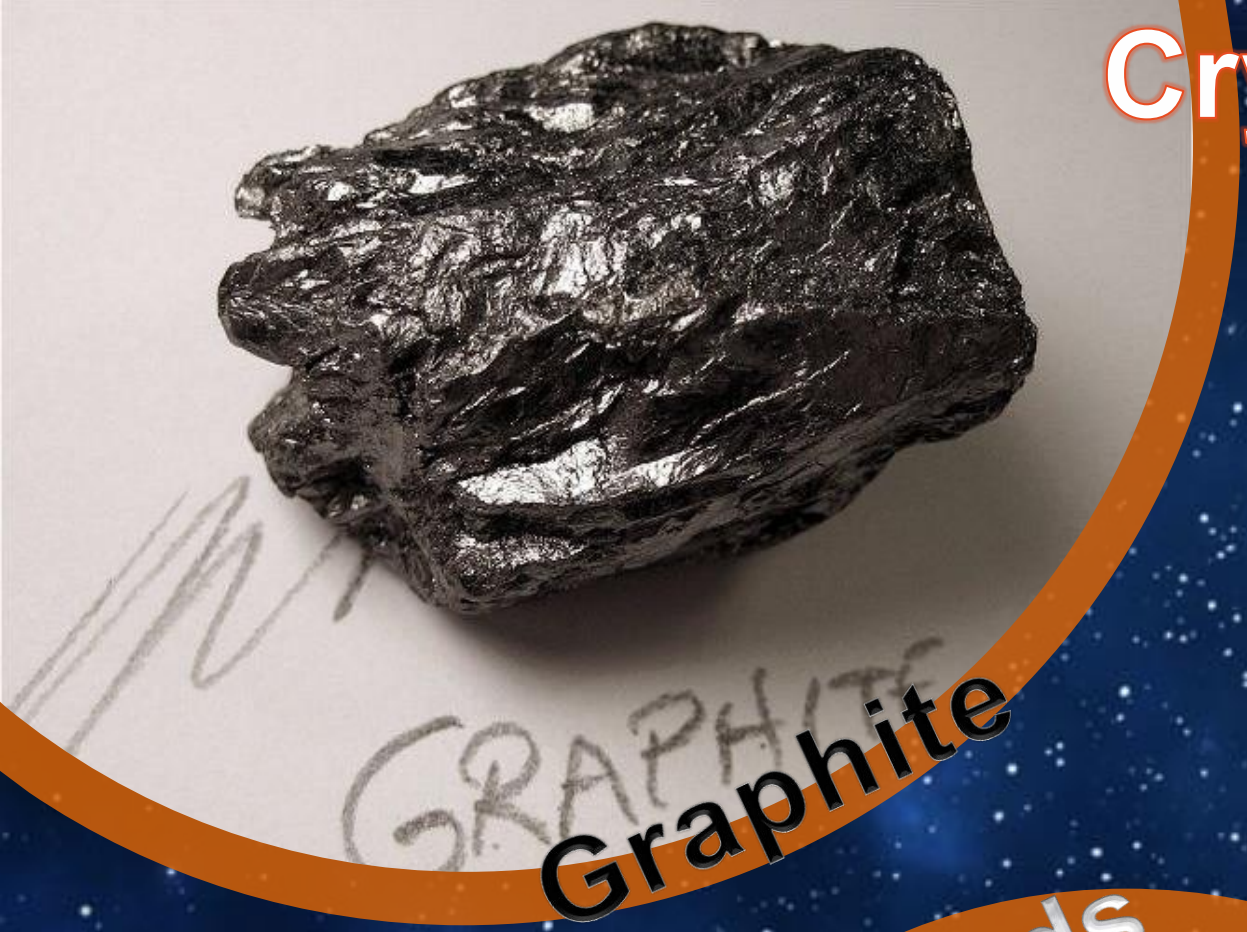


In other galaxies



Star death

Crystal structure matter

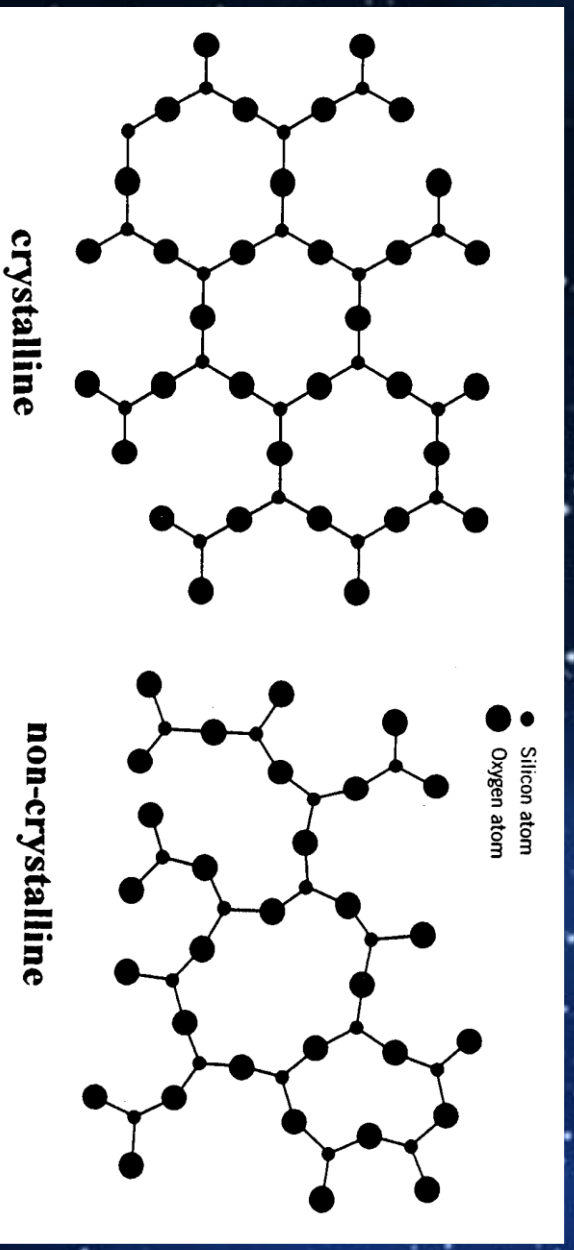


Graphite

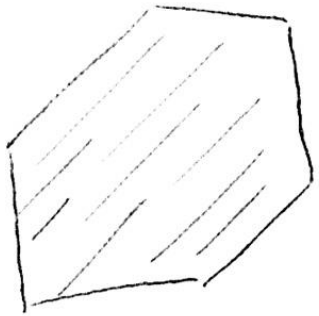
Amorphous Carbon

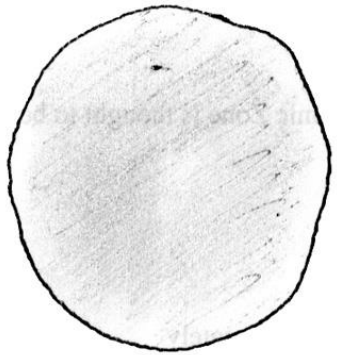
Diamonds

Crystalline vs. amorphous dust



Single Crystal
(ordered, anisotropic)



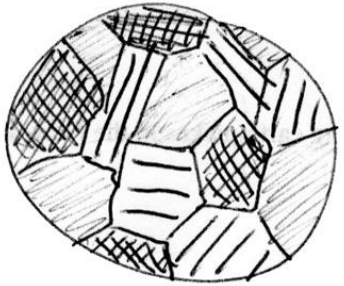


Glassy Grain
(disordered, isotropic)

Polycrystalline Grains

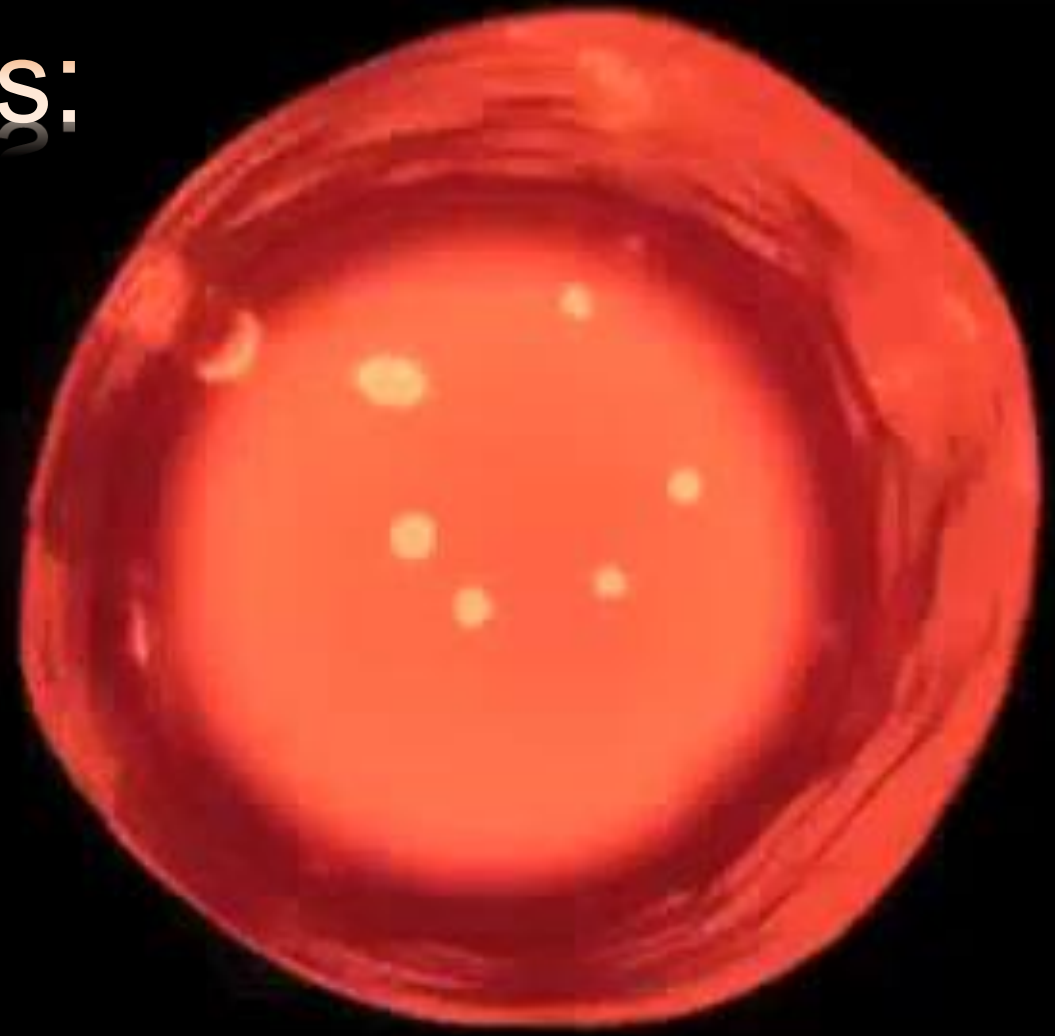
monomineralic

polymineralic



polymineralic including glass

Results:



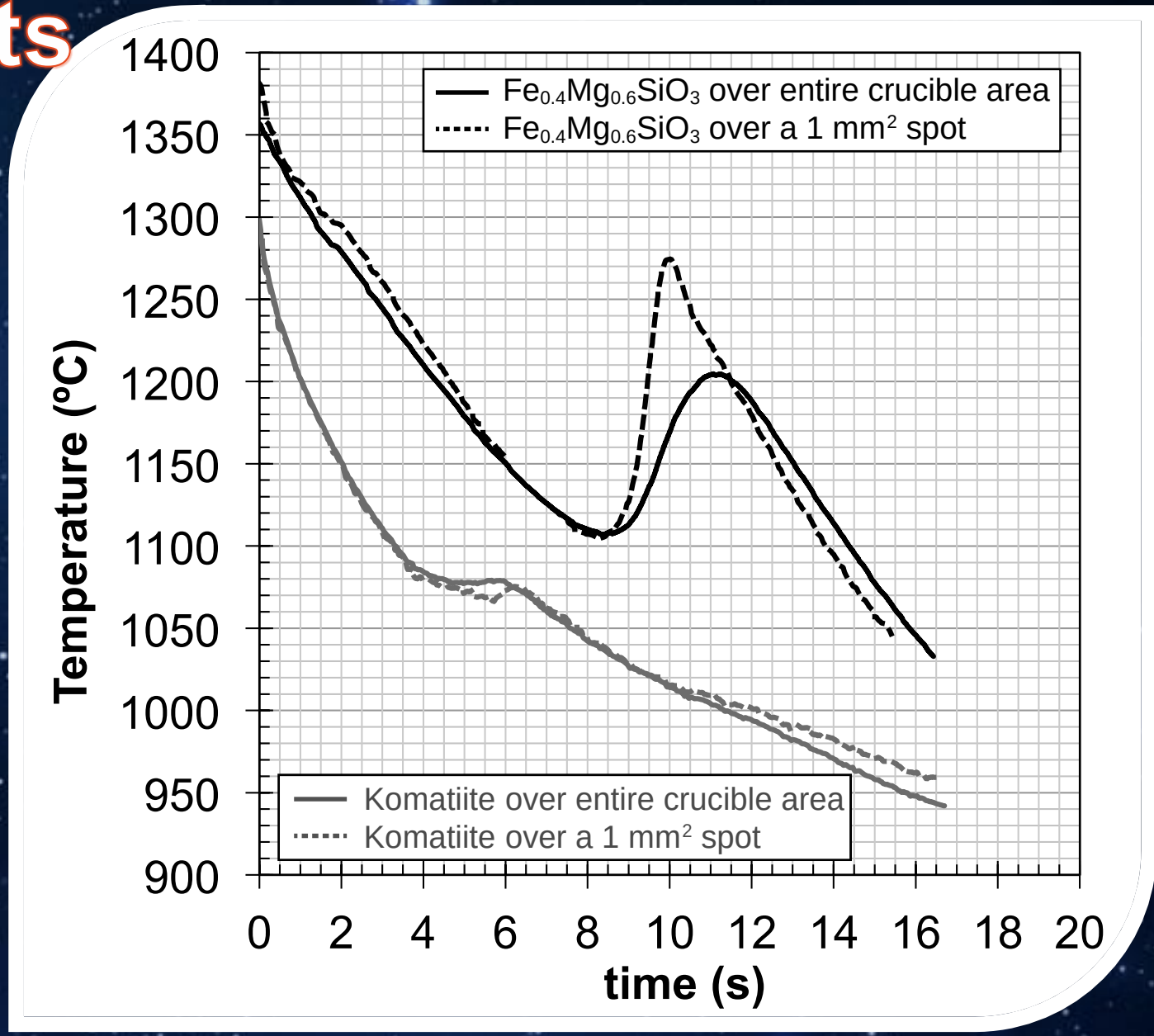
- As molten rock cools it nucleates crystals
- The formation of the crystals releases heat
- The crystals glow brightly compared to the surround liquid

Experimental Results

We studied the heating and cooling of mineral samples

$Fe_{0.4}Mg_{0.6}SiO_3$ is a similar to silicate space dust

On cooling, the material spontaneously heats up!



Energy release from crystallization

At ~1000 K curve goes –ve

Sample is generating heat from crystallization

→Shines brighter than surrounding

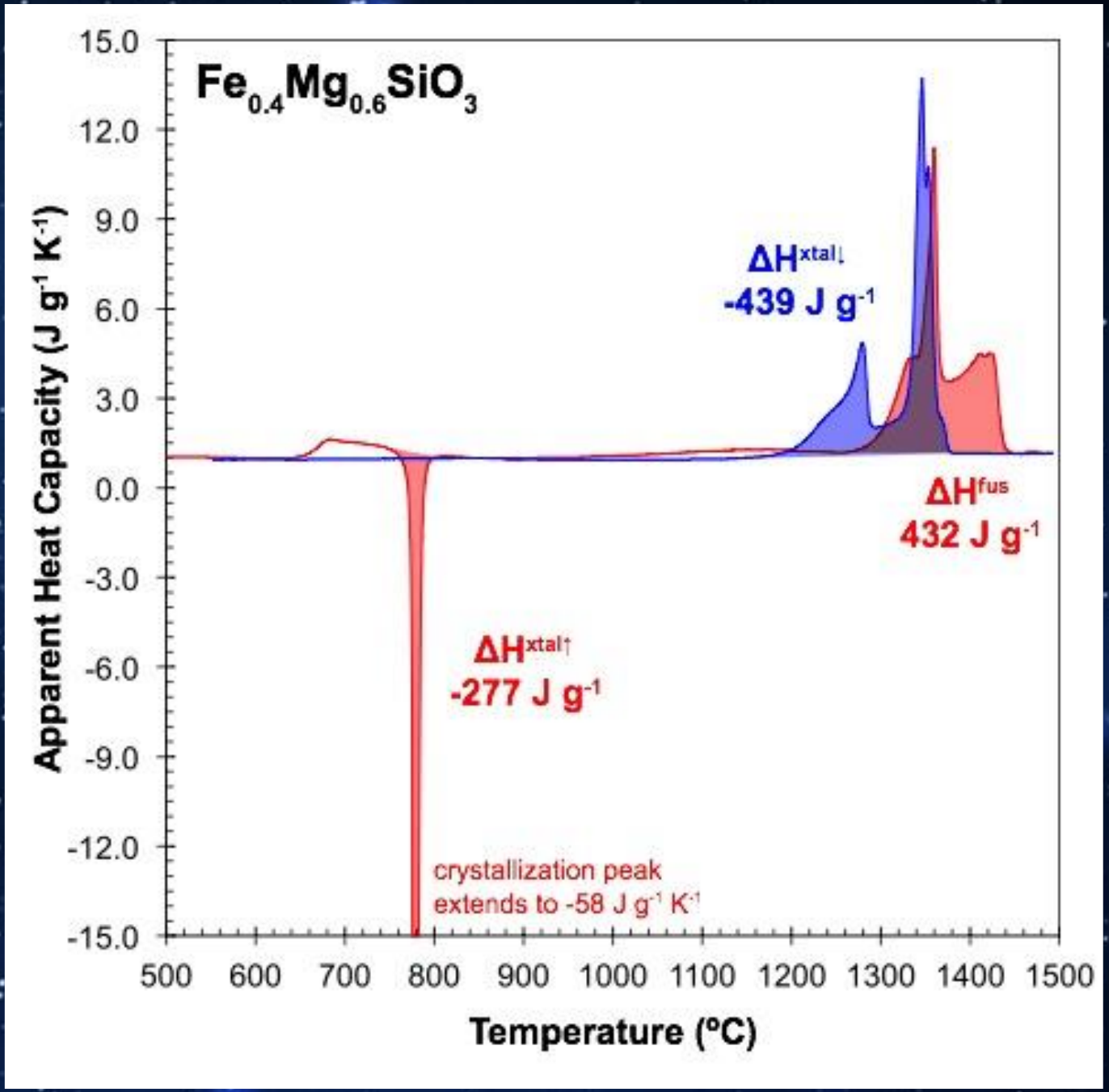
Brightness is proportional to T^4

Small change in T → big change in brightness

For space dust – grains at ~1000K may be able to crystallize

→heat up

→Shine more brightly than surrounding amorphous dust



Implications/Summary

- As dust forms it can crystallize
- The dust heats→ Brightens → easier to see
- Once it cools, crystalline features will be hidden.
- Dust forming around stars will show crystalline dust,
- Cool dust in the ISM will not.
- Solve the paradox
- Whether dust in crystalline or amorphous affects EVERYTHING!