Dust destruction and heating in the IGM

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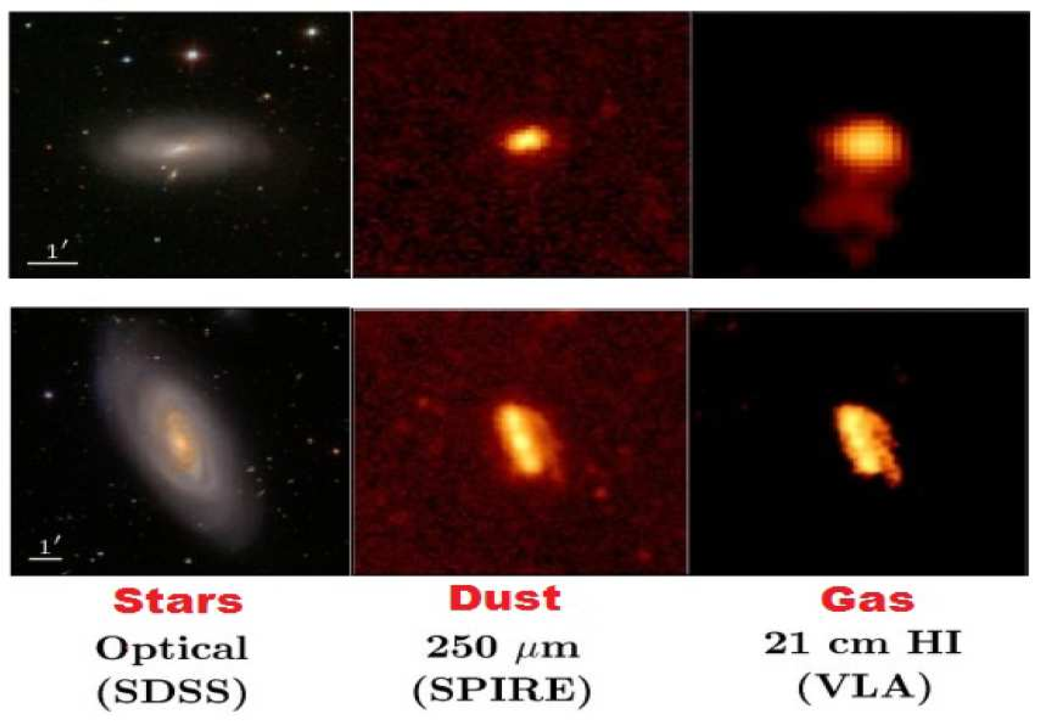
Scientific background

Observations of ram-pressure stripped galaxies in the Virgo Cluster have shown a correlation and an asymmetry of dust and gas profiles with respect to the galactic plane (e.g. [CDP+10]). Therefore, dust and gas pushed outside the boundaries of a galaxy will encounter a different, more tenuous and much warmer environment than the interstellar medium (ISM): the intergalactic medium (IGM).
Since the IGM is a very hot and tenuous medium ($T_{\rm gas} \approx 10^5 - 10^7$ K, $n_{\rm H} \approx 10^{-3} - 10^{-4}\,{\rm cm}^{-3}$), dust grains, due to the collisions with the energetic electrons, can be heated up or destroyed affecting the resulting dust SED ([BMGJ12] & [BJV+12]).

NGC 4424 (top panels) and NGC 4569 (bottom panels) in optical, 250μm and 21 cm bands ([CDP+10])



We notice that in the bottom panels there is a correlation between dust and gas emission and we can detect some dust outside the boudaries of the galaxy while in the top panels there is no evidence for dust outside the galaxy.
We want to understand which are the mechanisms that can explain this scenario.

References

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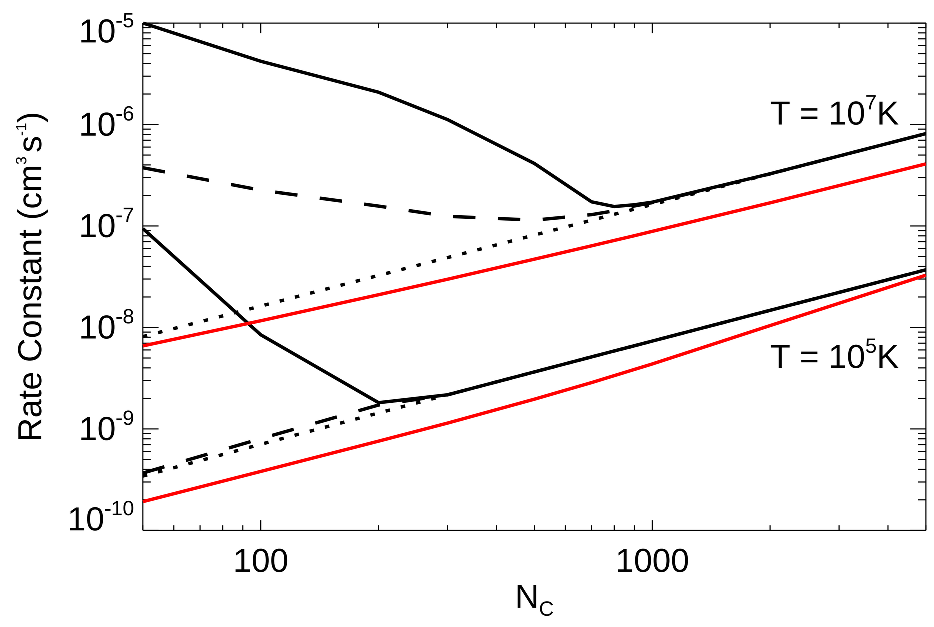
Dust destruction

In a hot gas, dust particles undergo erosion because of the collision with the energetic ions in the gas. This process is known as **thermal sputtering**.

- classical approach by [TMSH94] (red lines)
- modern approach by [MJT10] (black lines)

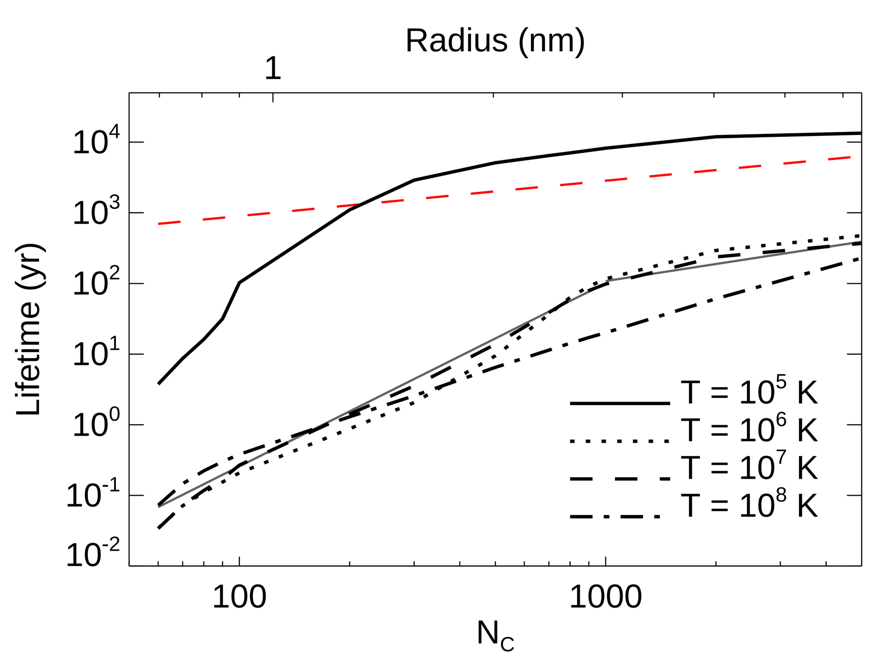
The classical approach is based on the mechanism of the collisional cascade inside a dust grain.
The modern approach includes the interaction between:

- gas ions and nuclei in the grain particle (**nuclear interaction**)
- gas ions and the electronic cloud in the grain particle (**electronic interaction**)
- electrons and the electronic cloud in the grain particle (**electron collisions**)



Rate constant ($dN_{\rm sp}/dt/n_{\rm H}$) as a function of the number of carbon atoms in the dust grain for different temperatures. Red lines: classical approach, black dotted lines: nuclear interaction, black dashed lines: nuclear + electronic interaction, black solid lines: nuclear + electronic interaction + electron collisions.
We notice we have an accordance between the rate constant calculated by the classical approach and the one calculated taking into account only the nuclear interaction. The big difference, for small grains, is given by the introduction of the electron collisions.

Lifetime (in years) of dust grains of different sizes for different gas conditions. Our results (black lines) are compared to the classical estimates [DS79] (red dashed line).



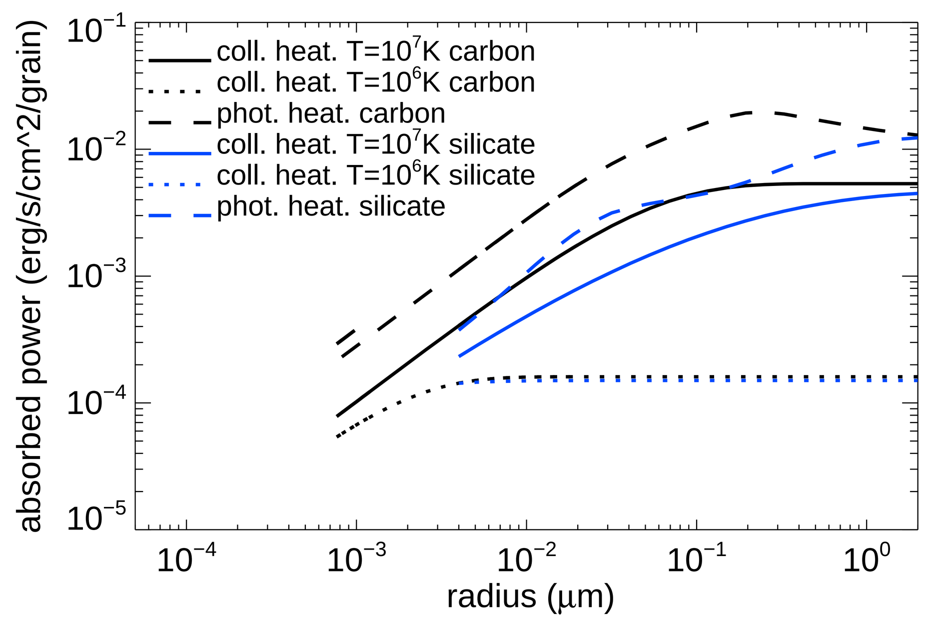
We notice that for the smallest dust grains there is a huge difference between the classical estimates and our results. This is due to the introduction of the electron collisions.

Dust heating

A dust grain, in the proximity of a galaxy, in the IGM can be heated by two processes:

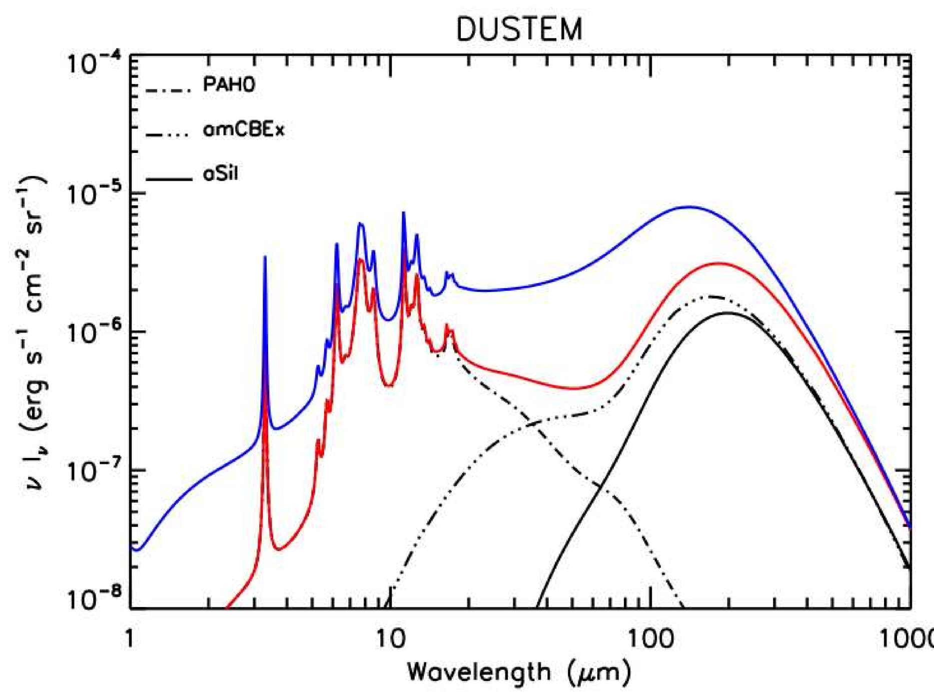
- **photon absorption**
- **electron collisions**

Power absorbed per grain for different grain radii due to photon ($G_0 = 1$) and electron collisional heating ($n_{\rm H} = 10^{-3}\,{\rm cm}^{-3}$ and $T = 10^6 - 10^7$ K).



The power absorbed due to collisions is less than one order of magnitude lower than in the case of photon heating! Going further from the galactic plane, the photon heating decreases and therefore the collisional heating starts to be the dominant heating process.

Dust SED for photon heating only (red line) and photon + collisional heating (blue line) where $G_0 = 0.1$, $n_{\rm H} = 10^{-3}\,{\rm cm}^{-3}$ and $T_{\rm gas} = 10^7$ K.



If we compare the blue line and the red line in the range of big grains ($\lambda \approx 100\mu$m), there is an excess of intensity in the case of photon + collisional heating and the temperature of big grains is higher than in the case of photon heating only.

In a hot gas ($T_{\rm gas} \approx 10^5 - 10^7$ K), and in particular in the IGM, collisions between dust grains and electrons play an important.
In these extreme conditions dust heating and dust destruction are coupled, we cannot have electron collisional heating without destruction and viceversa.