The Herschel Virgo Cluster Survey (HeViCS):

Dust Grain Lifetime in Early-Type Galaxies

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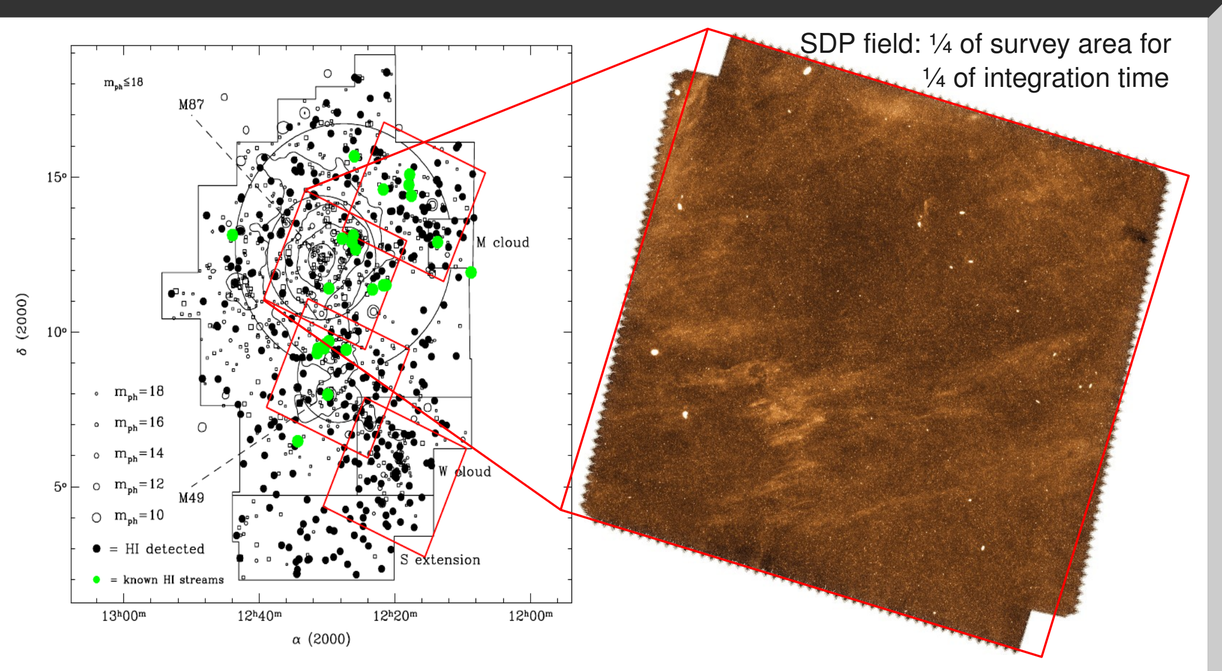
Passive early-type galaxies (ETGs) provide an ideal laboratory for studying the interplay between dust formation around evolved stars and its subsequent destruction in a hot gas. Using Spitzer-IRS and Herschel data we compare the dust production rate in the envelopes of evolved AGB stars with a constraint on the total dust mass. Early-type galaxies which appear to be truly passively evolving are not detected by Herschel. We thus derive a distance independent upper limit to the dust grain survival time in the hostile environment of ETGs of $< 46 \pm 25$ Myr for amorphous silicate grains. This implies that ETGs which *are* detected at far-infrared wavelengths have acquired a cool dusty medium via interaction. Given likely time-scales for ram-pressure stripping, this also implies that only galaxies with dust in a cool (atomic) medium can release dust into the intra-cluster medium.



Spitzer has shown that many early-type galaxies show signs of either on-going or recent past star formation, and are therefore not "passive" objects. We use Spitzer-IRS spectra to select only the most passive.

We assume that dust in passively evolving ETGs is produced only by AGB stars. This hot circumstellar dust has been detected by Spitzer-IRS (Bressan et al. 2006, ApJ, 639, L55) in the form of a silicate emission feature at 10μm.

From the silicate emission feature we measure the optical depth of the circumstellar envelope and, assuming a wind velocity of 10 km/s, we derive the dust production rate.

For the 6 galaxies observed with Spitzer that are in the Herschel SDP field we find dust production rates ~ 0.008 $M_\odot$/yr per 10^{12} $M_\odot$ of galaxy.

Silicate emission feature at 10μm

Optical depth

Assume stationary stellar wind around AGB stars

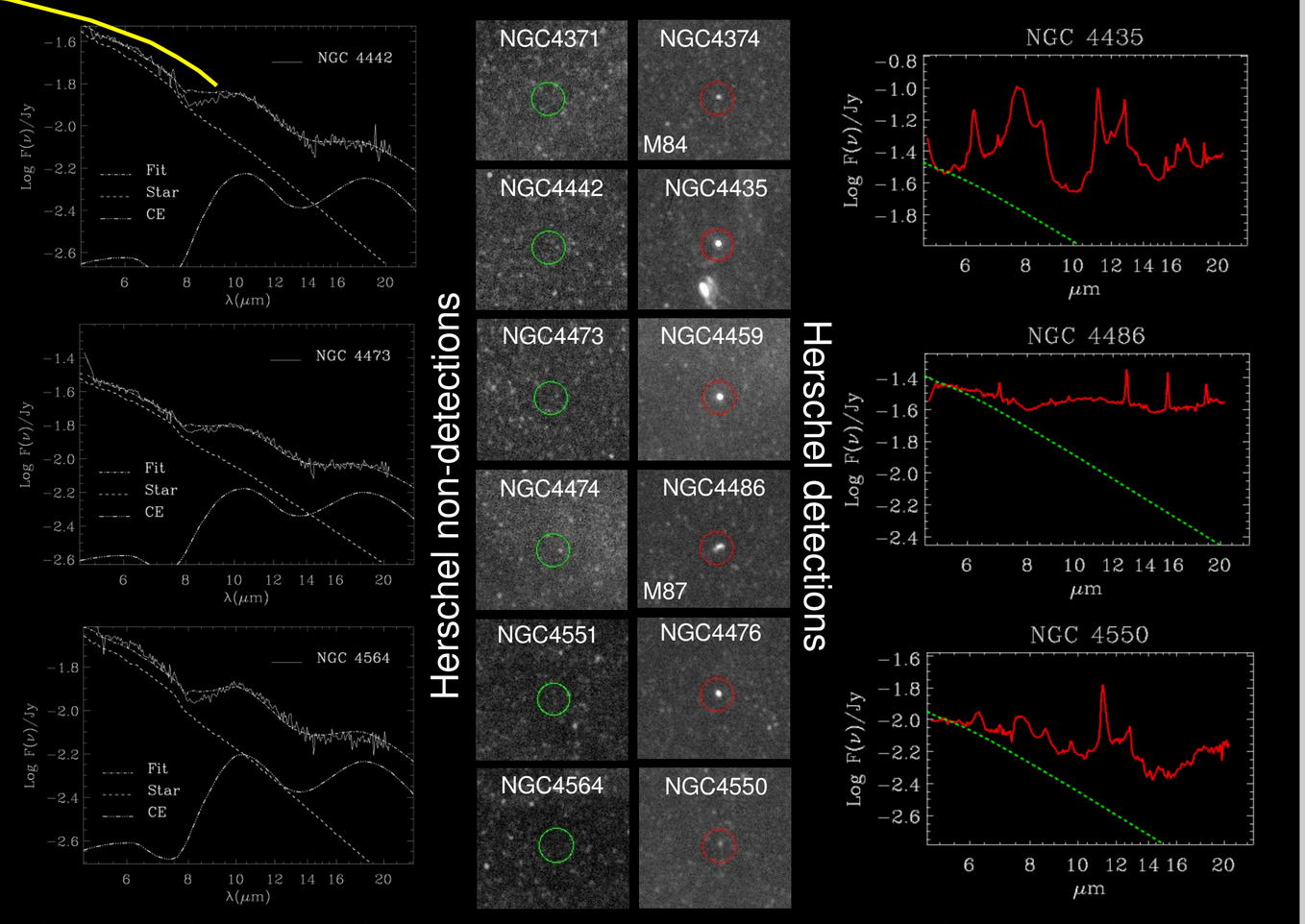
Derive the dust production rate

2σ dust mass detection limit from 250μm Herschel image: 9×10^3 $M_\odot$

Grain lifetime < (dust mass limit) / (dust production rate)

Grain lifetime < 46 ± 25 Myr

T*ruly passively evolving* early-type galaxies not detected by Herschel



"Passive" Spitzer-IRS spectra

"Active" Spitzer-IRS spectra

Timescales:

- Lowest observational limit on grain lifetime: < 46 Myr
- Theoretical estimate for sputtering (100 nm grains, hot gas density n=0.02 cm^3): ~1.5 Myr
- Ram-pressure stripping ~ 10^9 yr

∴ Dust is destroyed before it can escape a passive galaxy.

Conclusions:

- If a galaxy shows no sign of "activity" in its mid-infrared spectrum it is undetected in the far-infrared by Herschel.
- Passive ETGs show no evidence for a cool diffuse dust component.
- The dust grains are destroyed on time-scales shorter than those over which ram-pressure can act.
- *Passive* ETGs do not release dust into the intra-cluster medium.