The Fate of Nanodust near the Sun

Comparison of Sputtering and Sublimation lifetimes during CMEs

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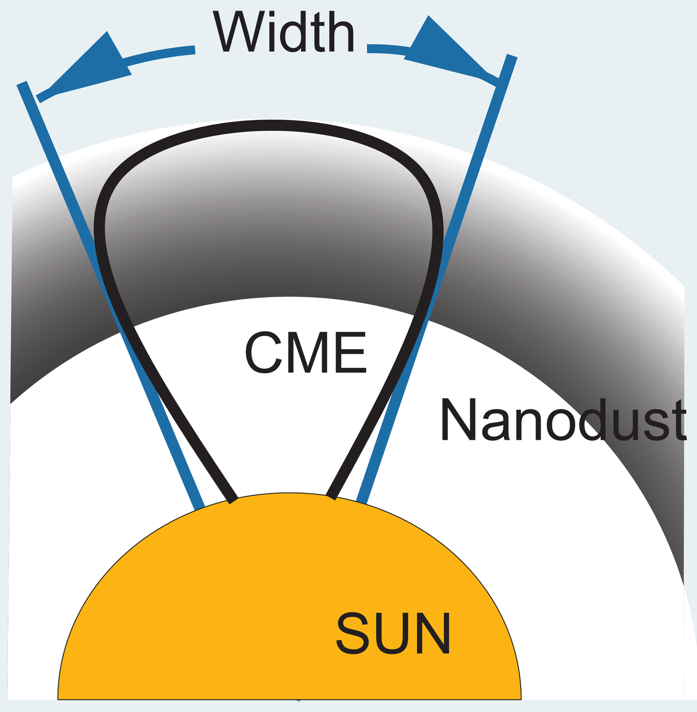
Motivation

Solar Orbiter (C) ESA

Parker Solar Probe (C) NASA

The dust environment in the inner Solar system has not been probed so far, but ESA's Solar Orbiter (2020) and NASA's Parker Solar Probe (2018) are about cross the inner solar system.
From [1] we expect a layer of trapper Nanodust around the Sun. [2] investigated the interaction of grains with the Solar wind. But what is the dust's fate when they are struck by a Coronal Mass Ejection (CME). Are they destroyed by sputtering from impacting ions or rather sublimate near the sun. This work investigates wheter CME's deplete the Nanodust population locally.



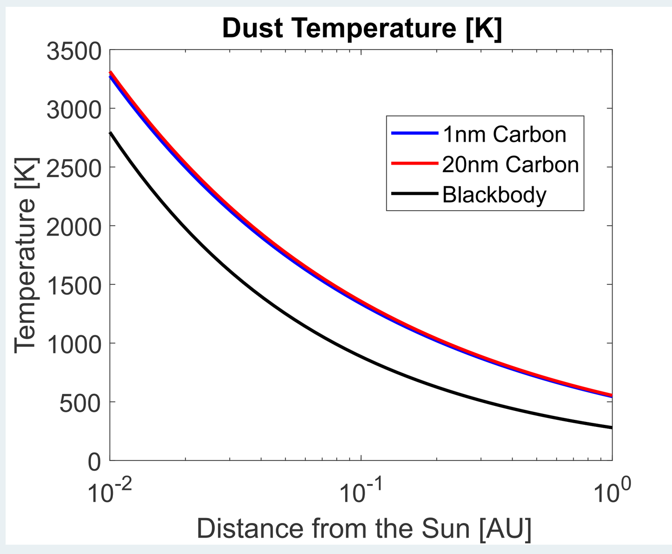
Sublimation

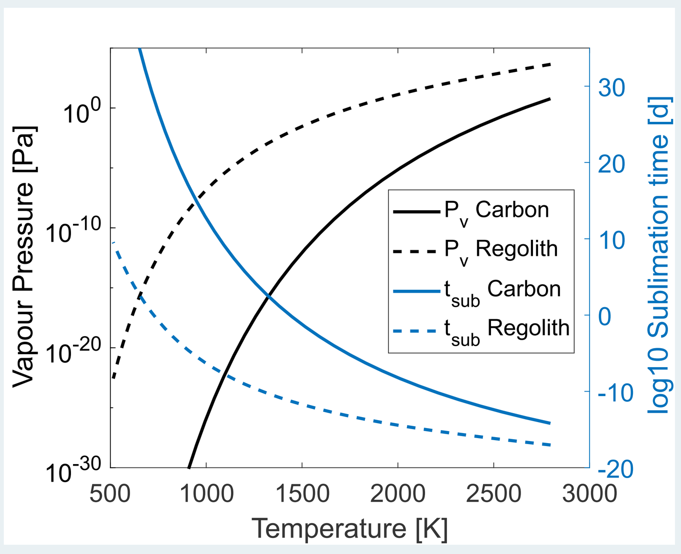
- Equilibrium temperatures using standard blackbody and Mie calculations for Carbon grains
- derive sublimation lifetime from Langmuir equation

$$t_{sub}(d) = \frac{r_0 \rho}{p_v(d)} \sqrt{\frac{2\pi R T(d)}{M}}$$

p_v - Vapour Pressure
ρ - particles mass density

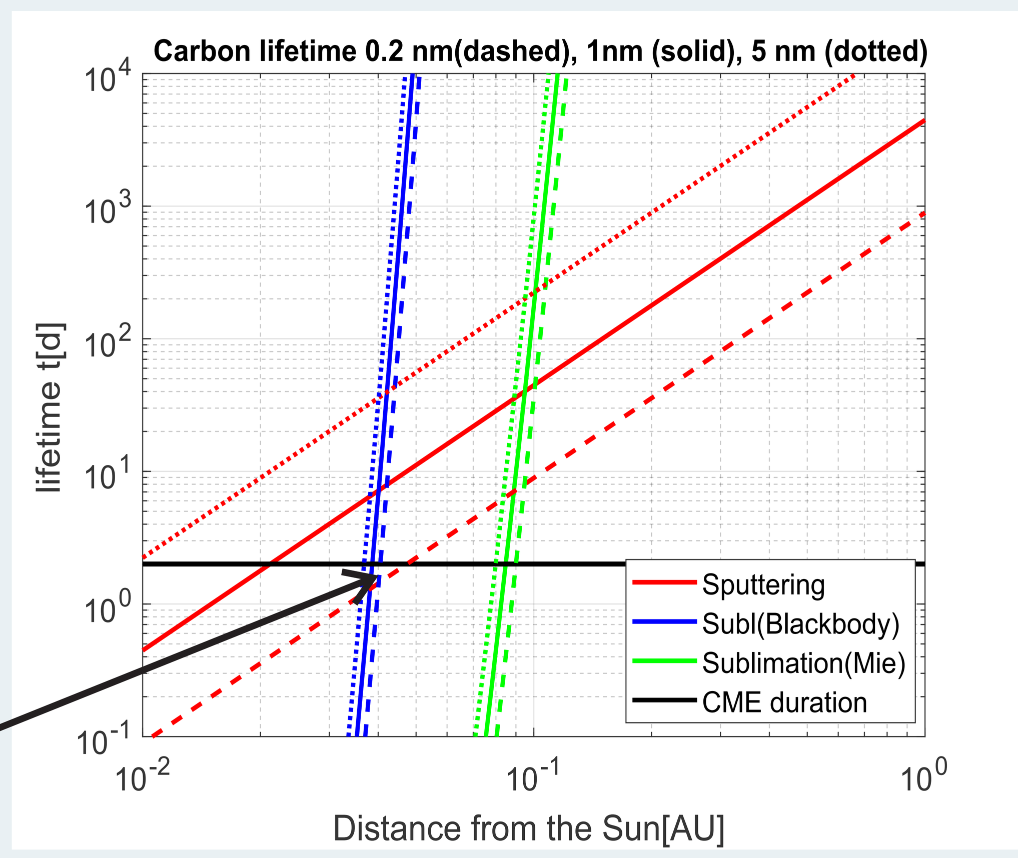
- carbon vapour pressure from [5]
- apply MAGMA code [4] for other grain compositions (e.g. Regolith)





Comparison of Lifetimes

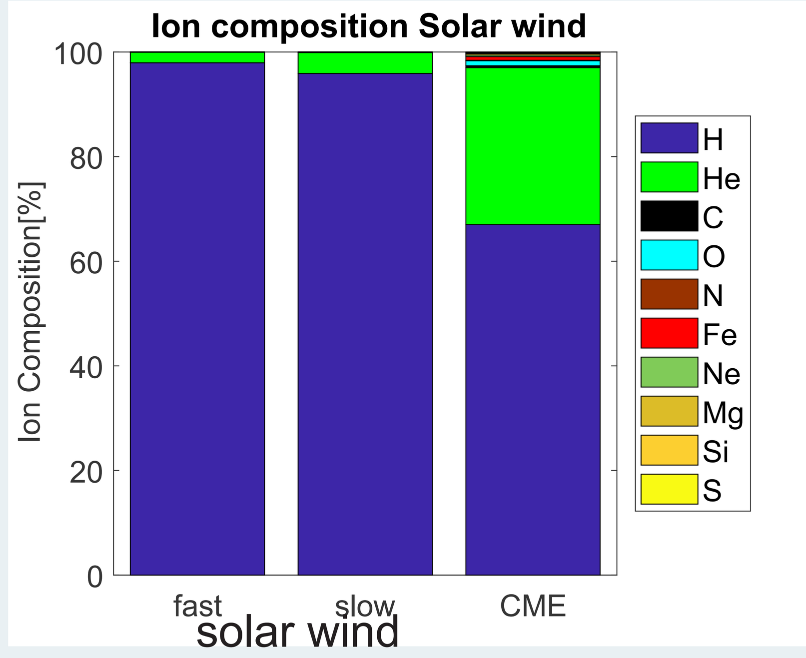
- Sputtering lifetimes depend on the initial grain sizes
- Sublimation lifetimes is depend strongly on temperature/vapour pressure
- only for very small carbon grains (0.2nm), sputtering during a CME leads to dust destruction at a certain distance



- future work will characterize other relevant grain compositions

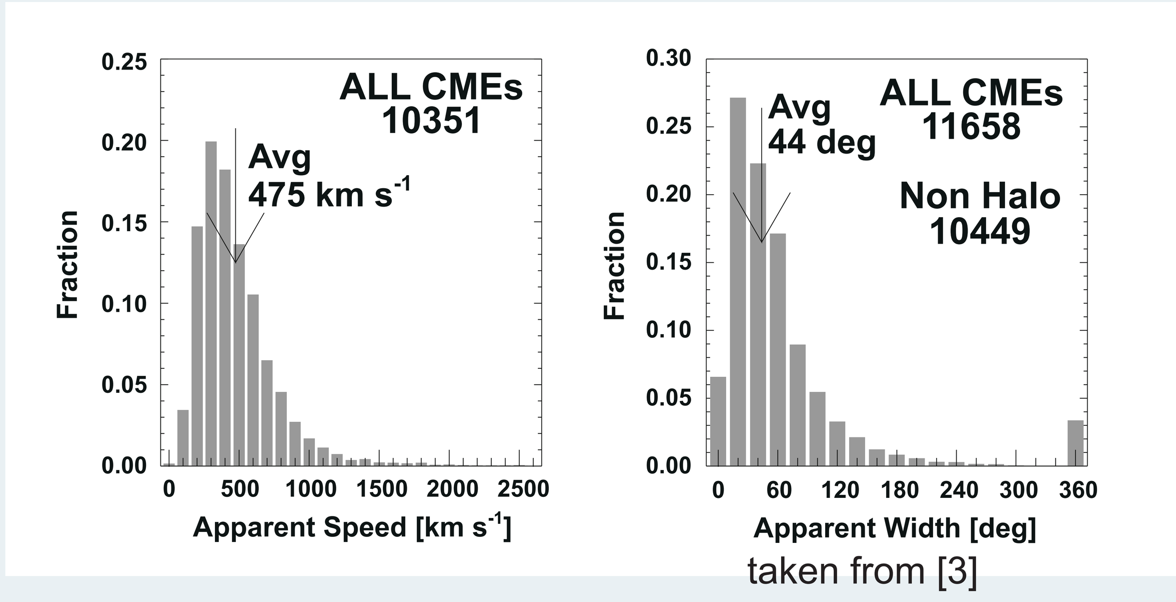
CME properties and sputtering

- Composition of the Solar wind is not uniform, mainly H and He ions
- CME contain a significant amount of heavier ions
- Solar wind speed varies
  fast SW ~800km/s
  slow SW ~300km/s
  CME ~500km/s

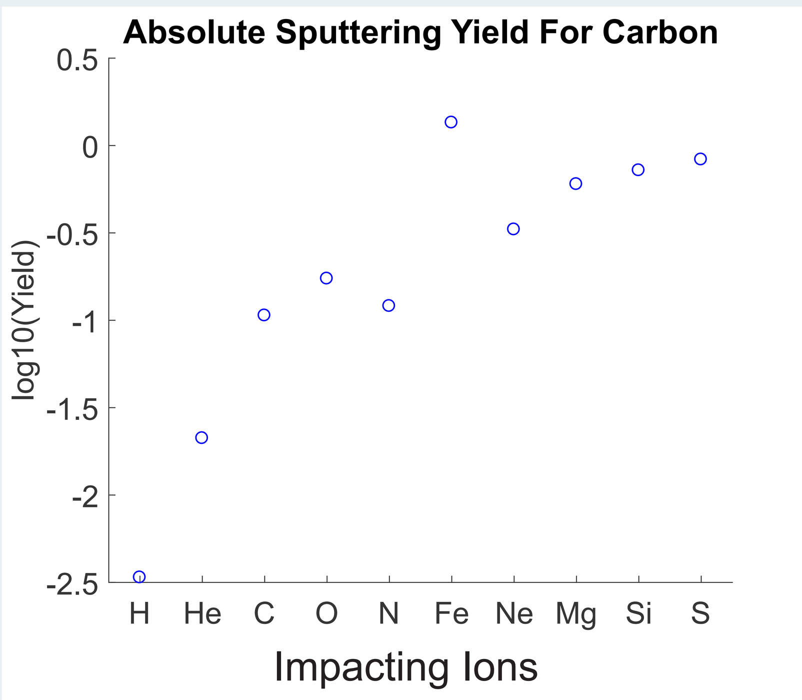


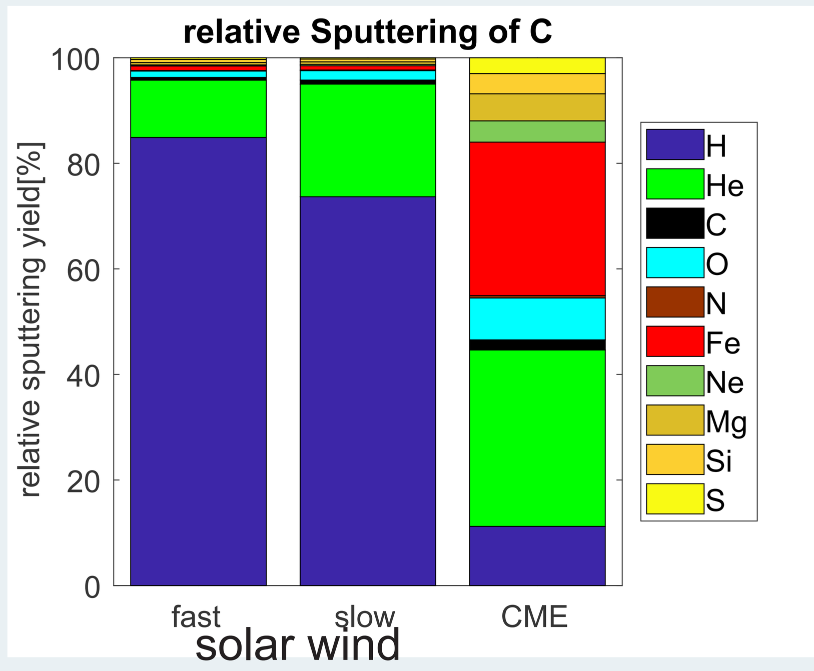
- $\sim 3 cm^{-3} \sim 8 cm^{-3} \sim 70 cm^{-3}$
  plasma density at 1AU

- quasi permanent solar wind
- during high solar activity 1-2 CMEs/day
- ~14% of the space is affected by one CME (from solid angle)



taken from [3]



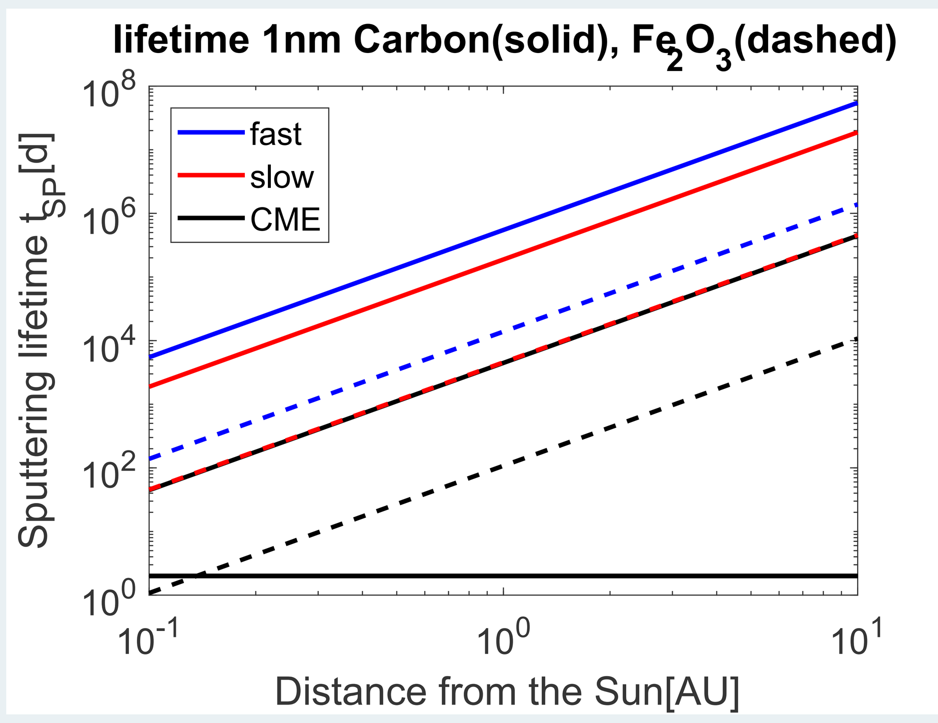


- sputtering Yield is a function of dust composition and ion weight and speed
- when weighing the sputtering yield with CME composition, the importance of heavier ions is evident

$$t_{sput}(d) = \frac{4 r_0 \rho N_A}{f_{SW}(d) Y_{tot} M}$$

f_{SW} - Solar wind flux
Y_{tot} - total sputtering Yield

- t_{sput} has a strong dependence on particle composition
- using the TRIM package [2] to derive Yields for different compositions (e.g. FeO/MgO)



References

[1] A. Czechowski and I. Mann, Formation adn Acceleration of Nano Dust in the Inner Heliosphere, *The Astrophysical Journal* (2010)

[2]T. Mukai and G. Schwehm, Interaction of Grains with the Solar Energetic Particles, *Astron. Astrophys.*, (1981)

[3] N. Gopalswamy et al., The SOHO/LASCO CME catalog , *Earth Moon Planets (2009)*

[4] J Ziegler et al., TRIM/SRIM package (www.srim.org)

[5] B. Fegley and A.G.W. Cameron, A vaporization model for iron/silicate fractionation in the Mercury protoplanet, *Earth and Planetary Science Letters* (1987)

[6] David R. Lide (ed), CRC Handbook of Chemistry and Physics, 84th Edition. CRC Press. Boca Raton, Florida, 2003; Section 6 Fluid Properties; Vapour Pressure