LMC: Dust Input from AGB stars at sub-solar metallicities

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Abstract

The dust-forming population of AGB stars and their input to the interstellar dust budget of the Large Magellanic Cloud (LMC) are studied with evolutionary dust models with the main goals (1) to investigate how the amount and composition of dust from AGB stars vary over the galactic history; (2) to characterise the mass and metallicity distribution of the present population of AGB stars; (3) to quantify the contribution of AGB stars of different mass and metallicity to the present stardust population in the ISM. For the first time, theoretically calculated dust production rates of AGB stars are compared with those derived from infrared observations of AGB stars for the entire galaxy. We show that the majority of silicate and iron grains in the present stardust population originate from a small population of intermediate-mass stars consisting of only 4% of the total number of stars, whereas in the solar neighbourhood the parent stars have bimodal mass distribution with a large contribution from low-mass stars. With models of the lifecycle of stardust grains in the LMC, we confirm the strong discrepancy between dust input from stars and the existing interstellar dust mass in the LMC.

Motivation and Objectives

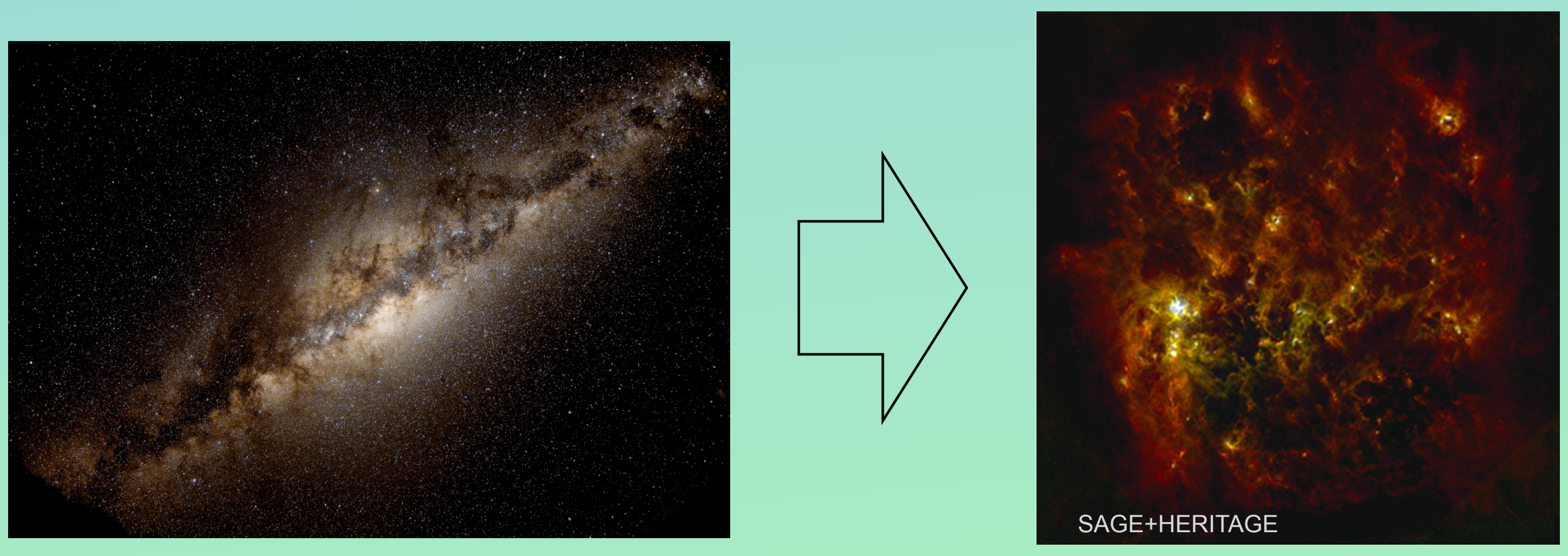


Fig. 1 Dust and gas spatial distribution in the Milky Way (**left**) and the Large Magellanic Cloud (**right**). We apply dust evolutionary models tested on the Milky Way to study grain origin and cycle in the LMC.

In the Milky Way stars make a minor contribution to dust budget, NEED of additional source → dust growth by accretion of atoms in the ISM→ **critical dependence on metallicity** (Zhukovska+2008, Draine 2009)

Missing dust source problem in LMC: mid-infrared observations of AGB stars with SST revealed that accumulated stardust mass 5×10^4 M_{sun} << observed dust mass 1.6×10^6 M_{sun} (Matsuura et al 2009)

◆ *What are contributions to interstellar dust budget of different stellar sources at subsolar metallicity?*

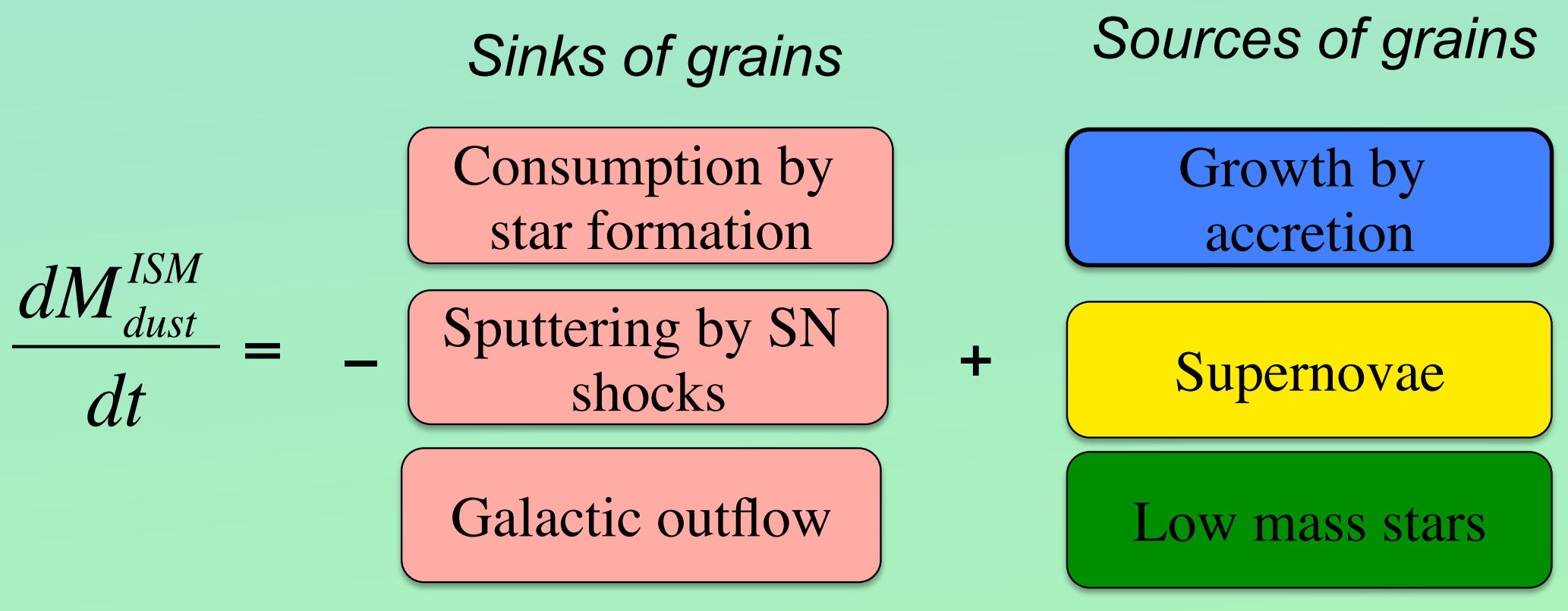
◆ *What is the present population of AGB stars?*

◆ *How does parent dust-forming population of the ISM grains depends on metallicity?*

Model

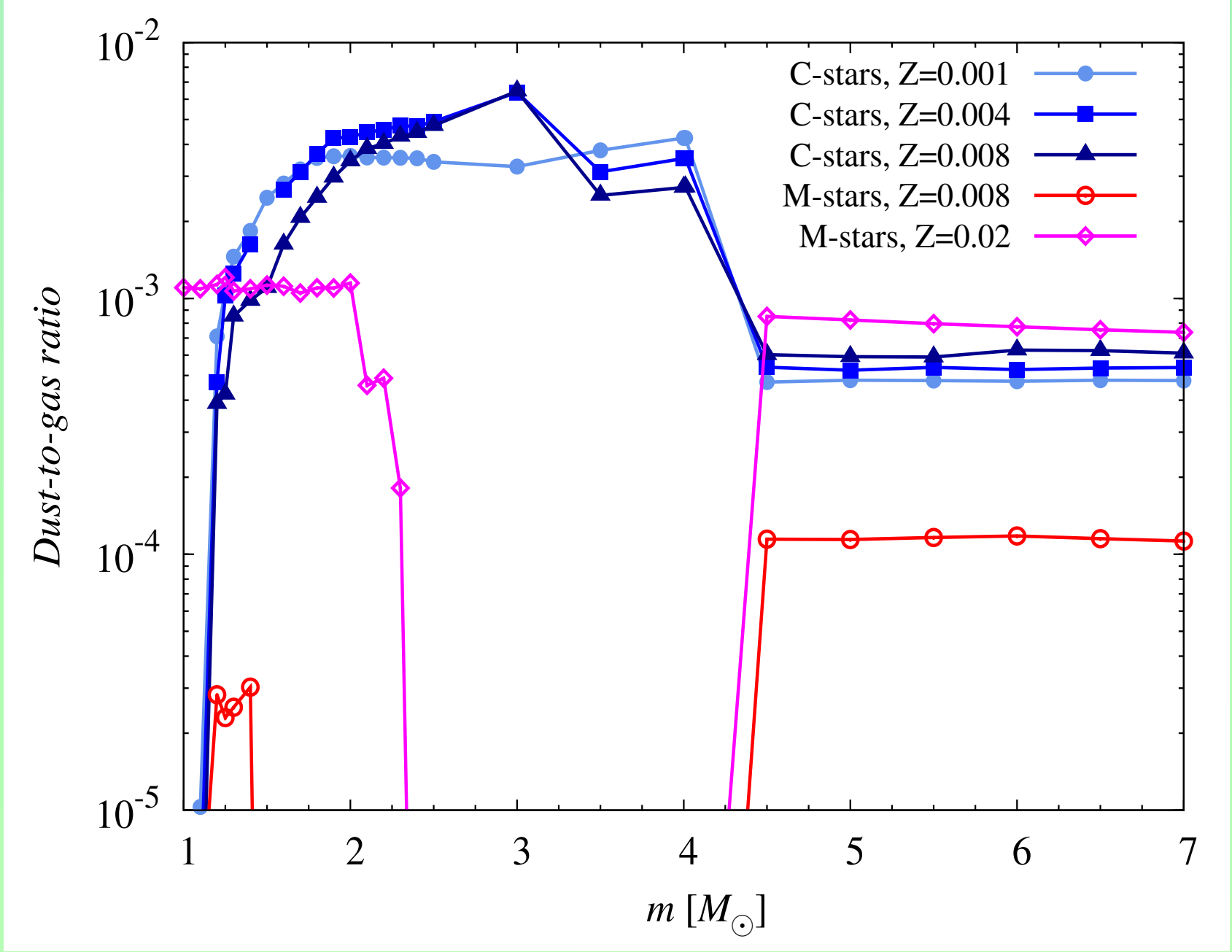
➢Global evolution model of dust and gas abundances in the ISM applied for the Solar neighborhood (Zhukovska S+2008, Gail+2009), and the Galactic disk (Zhukovska S. 2008)

➢ Star Formation history reconstructed from the MCPS (Harris&Zaritsky 2009)



Sinks of grains · *Sources of grains*

$$\frac{dM^{ISM}_{dust}}{dt} = -\begin{bmatrix}\text{Consumption by star formation}\\ \text{Sputtering by SN shocks}\\ \text{Galactic outflow}\end{bmatrix} + \begin{bmatrix}\text{Growth by accretion}\\ \text{Supernovae}\\ \text{Low mass stars}\end{bmatrix}$$



➢Dust input: M_*-, Z_*-dependent yields for carbon, silicate, SiC, iron dust species (Ferrarotti&Gail 2006, Zhukovska+2008)

Fig. 2 Dust-to-gas ratio in the circumstellar shell at the end of M-star and C-star evolution for various initial stellar metallicities from calculations by Ferrarotti & Gail (2006) and Zhukovska et al. (2008)

Results: Stardust injection rate

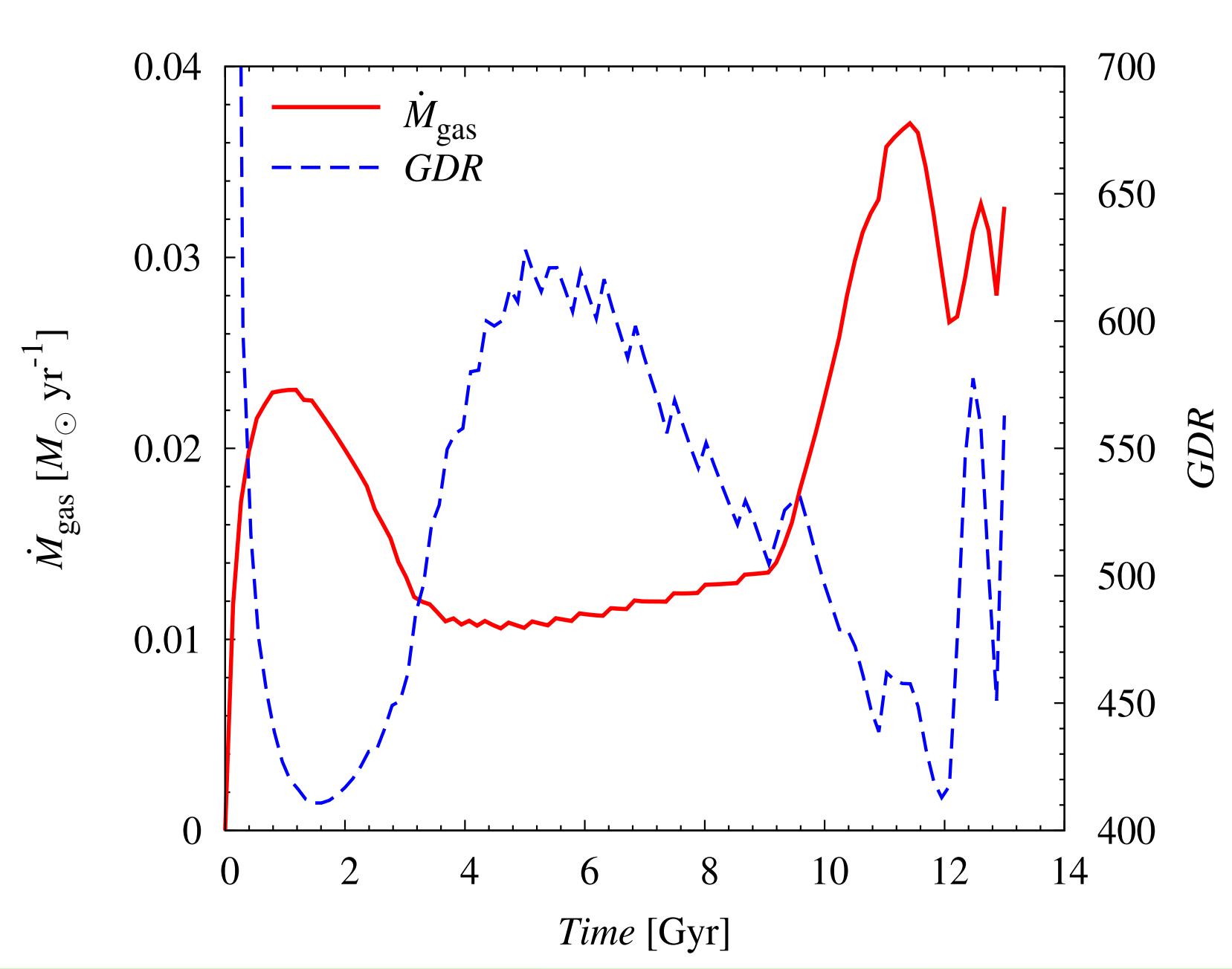


Fig. 3 Variations of the total gas injection rate by AGB stars reflects the star formation history of the LMC. The total gas-to-dust mass ratio GDR in stellar ejecta demonstrates that the AGB stars eject most dust-rich material during bursts of star formation (Zhukovska&Henning 2013).

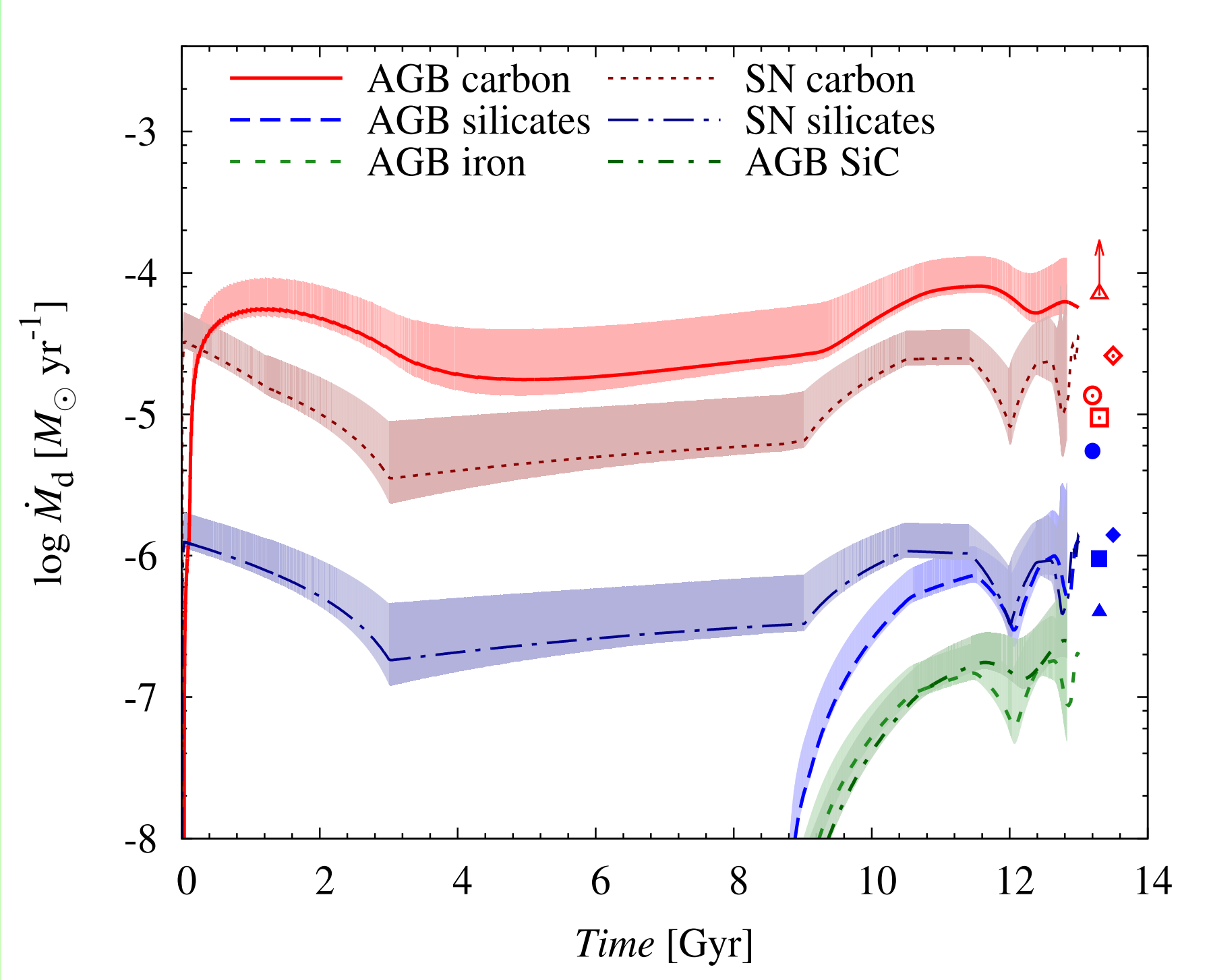


Fig. 4 Time evolution of dust production rates by AGB stars and Supernovae. Theoretically predicted dust injection rates from AGB stars agree well with estimates from observations with *SST* (different symbols). Stardust ejection is dominated by carbon dust from AGB stars, and only the first 200Myr from SNe type II (Zhukovska&Henning 2013).

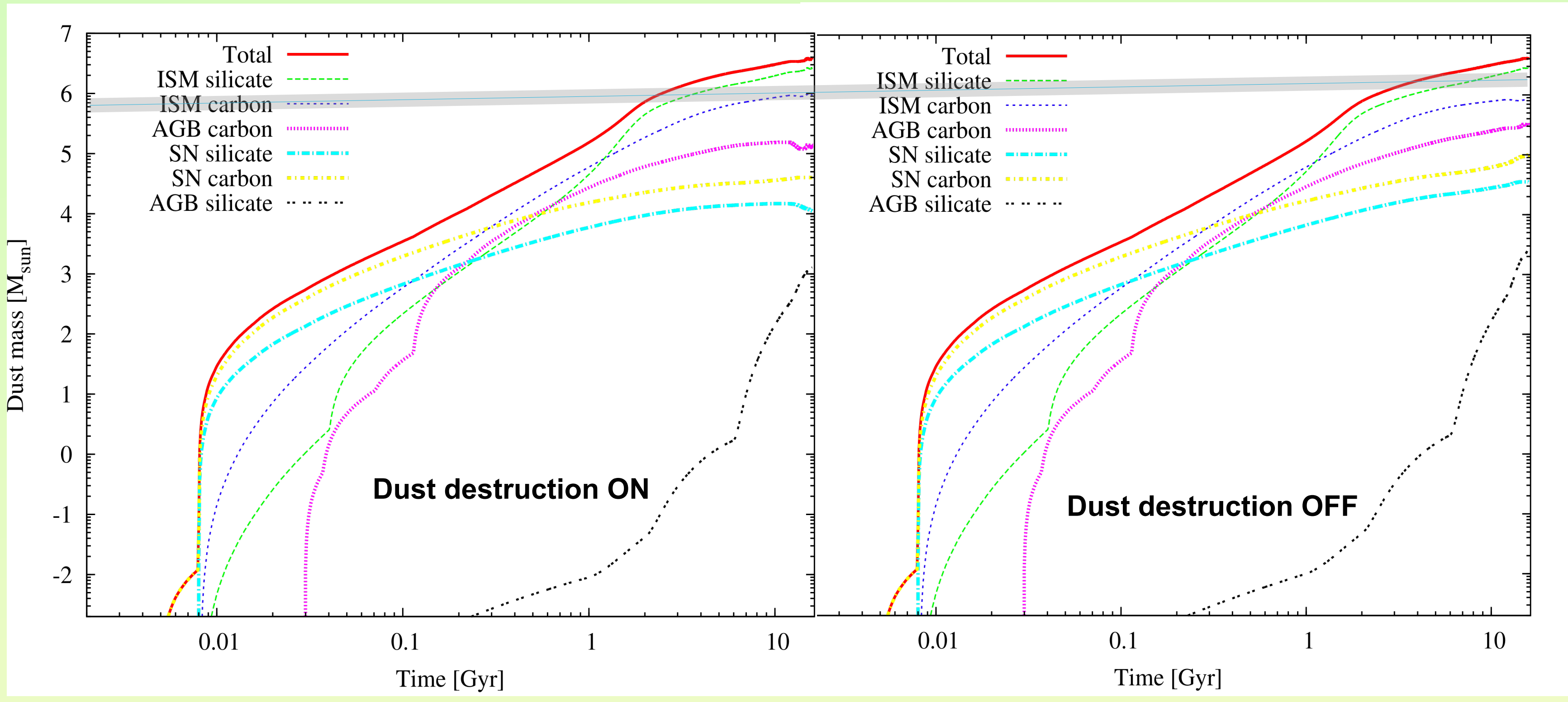


Fig. 5 Time evolution of silicate and carbonaceous dust of different origin with destruction in the ISM by SN shocks (left) and without destruction (right). Even without SN destruction, the stardust mass at the present time is smaller than the total interstellar dust mass in the LMC, 1.1-2.5 × 10^6 $M_\odot$ (gray line). Only with dust growth by accretion in the ISM, we can reproduce the present day interstellar dust mass in the LMC. However, the fraction of stardust is higher in the LMC compared to our Galaxy (3.4−7.7% vs. 1.5-2%)

Results: charactering AGB stars-dust producers

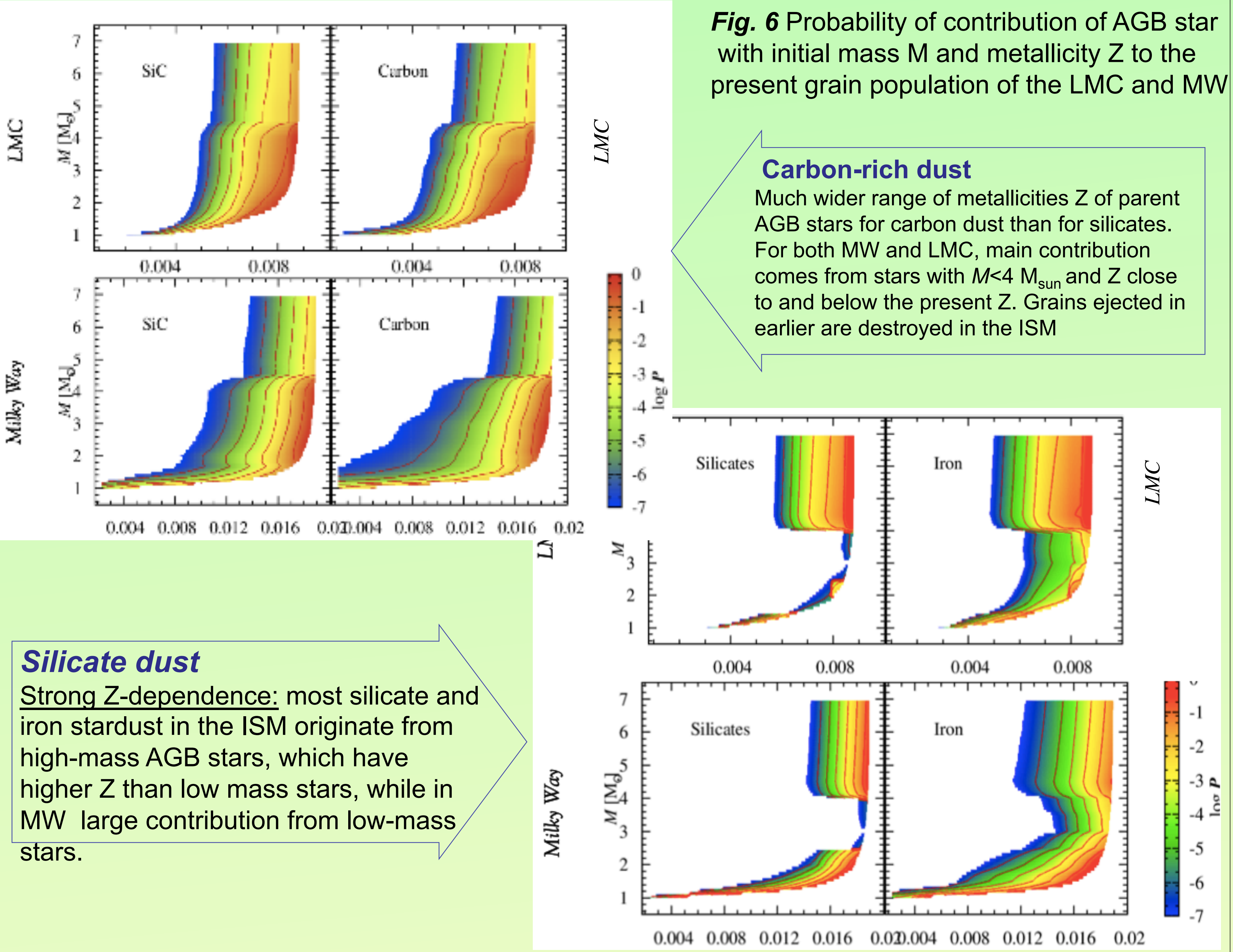


Fig. 6 Probability of contribution of AGB star with initial mass M and metallicity Z to the present grain population of the LMC and MW

Carbon-rich dust

Much wider range of metallicities Z of parent AGB stars for carbon dust than for silicates. For both MW and LMC, main contribution comes from stars with $M<4$ M_{sun} and Z close to and below the present Z. Grains ejected in earlier are destroyed in the ISM

Silicate dust

Strong Z-dependence: most silicate and iron stardust in the ISM originate from high-mass AGB stars, which have higher Z than low mass stars, while in MW large contribution from low-mass stars.

References

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Questions? Ask me!
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