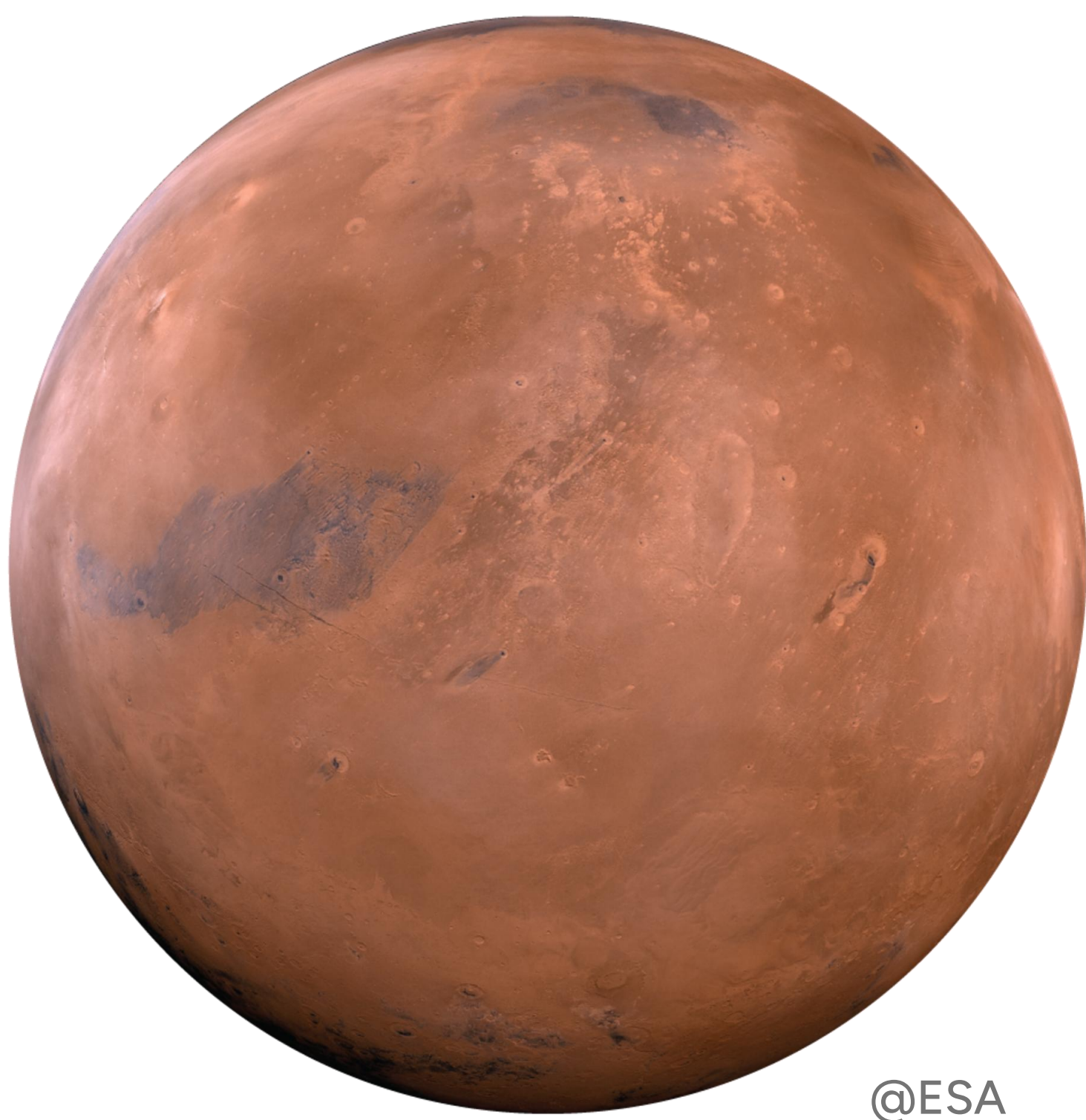


Pneumatic mobility and size classification of regolith particles under Martian environmental conditions

Mateo Rejón López^{1†}, Paul Zabel¹

¹German Aerospace Center (DLR), Institute of Space Systems, Bremen, Germany

[†]ORCID: 0009-0001-2388-4262 · mateo.rejonlopez@dlr.de



@ESA

A thin atmosphere that lifts, transports and sorts. Can we use it?

Martian winds constantly exchange regolith between the surface and atmosphere, shaping the planet's climate. In this thin CO₂ regime the gas mean free path comes close to fine-grain size, yet it still lifts and sorts grains. Could that same gas be harnessed for regolith handling in *In-Situ Resource Utilization* (ISRU)?

Grain size and slip set what moves

Martian grains are non-spherical in an atmosphere whose mean free path ($\lambda \approx 9.6 \mu\text{m}$) approaches the fine-grain size [1]. Below 100 μm the flow enters the slip regime and takes the Cunningham correction [2]. Balancing drag against gravity gives each grain's terminal velocity, setting what the wind lifts and how it sorts.



Martian dust devil @NASA/JPL-Caltech/Univ. of Arizona

On Mars, the wind is already a size classifier

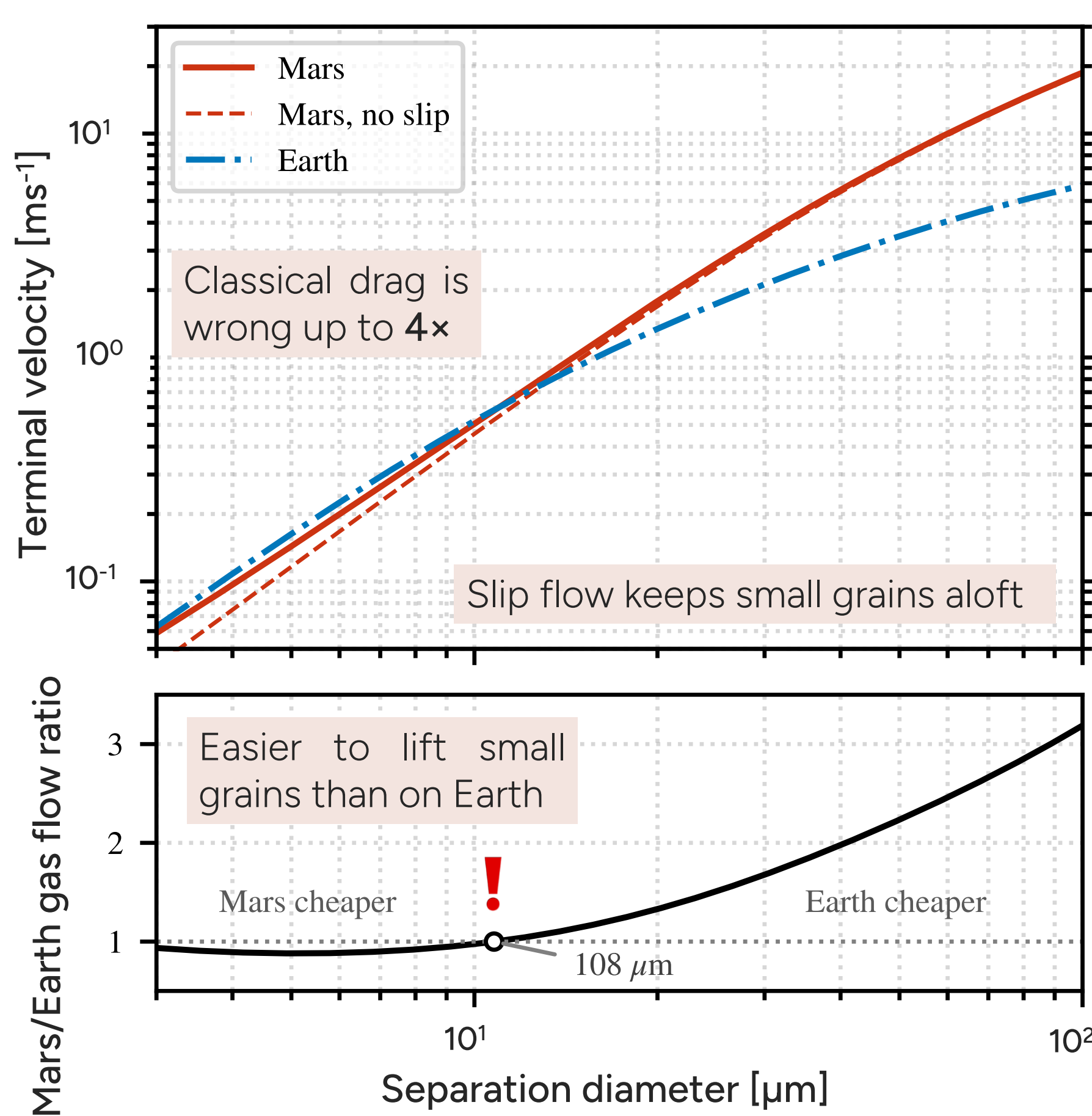


Fig. 1 – Terminal velocity as a function of separation diameter.

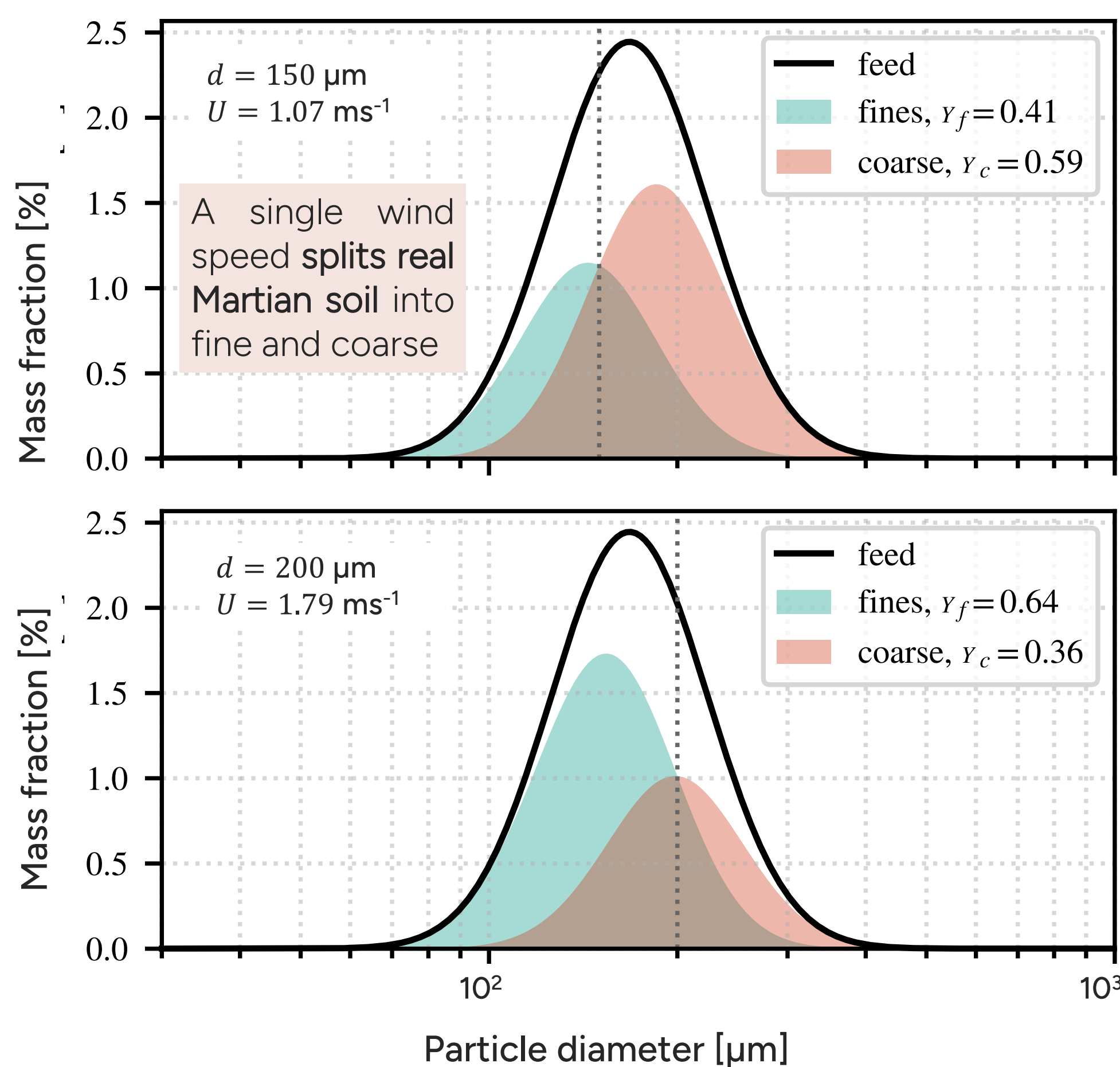


Fig. 2 – Particle size distribution (PSD) split due to gas entrainment. PSD from in-situ data [3].

Different environments

Symbol	Description	Value
<i>Martian Atmosphere</i>		
μ_M	Dynamic viscosity	$1.05 \cdot 10^{-5} \text{ Pa s}$
ρ_M	Gas density	0.015 kg m^{-3}
<i>Earth Atmosphere</i>		
μ_E	Dynamic viscosity	$1.81 \cdot 10^{-5} \text{ Pa s}$
ρ_E	Gas density	1.20 kg m^{-3}
<i>Mars Regolith</i>		
ρ_p	Particle density	2500 kg m^{-3}
ϕ	Particle sphericity	0.9

An ISRU opportunity

Mars ISRU has inherited lunar architectures, designed for a world with no atmosphere. Mars has one. These results show that same gas can be put to work handling regolith.

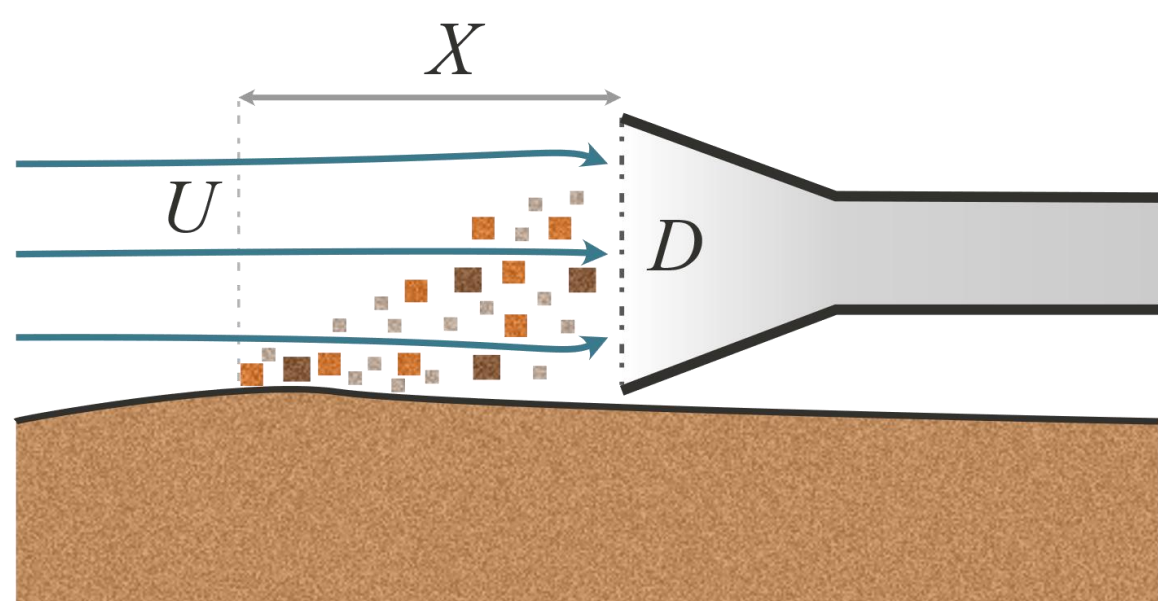
Mars atmospheric gases can be used for regolith handling: collection, transport and size classification

Pneumatic collection

Bulk collector

Not size-selective
(cohesion-limited)

~30–70 W

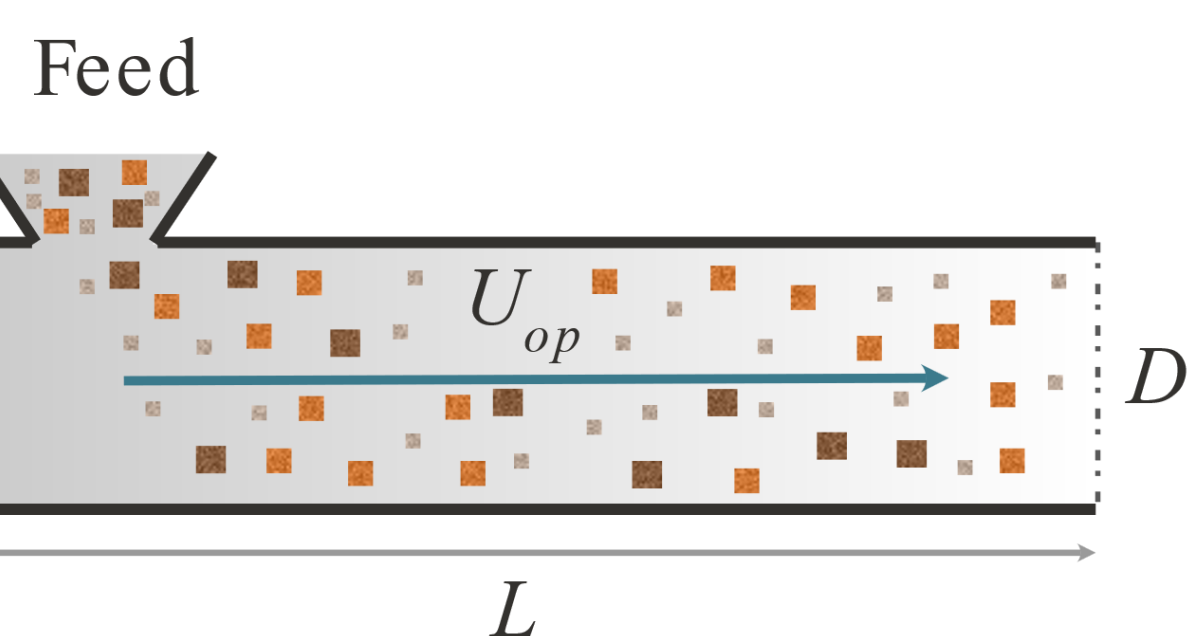


Pneumatic transport

Fine fraction only

Not competitive against
mechanical conveying

~65 W



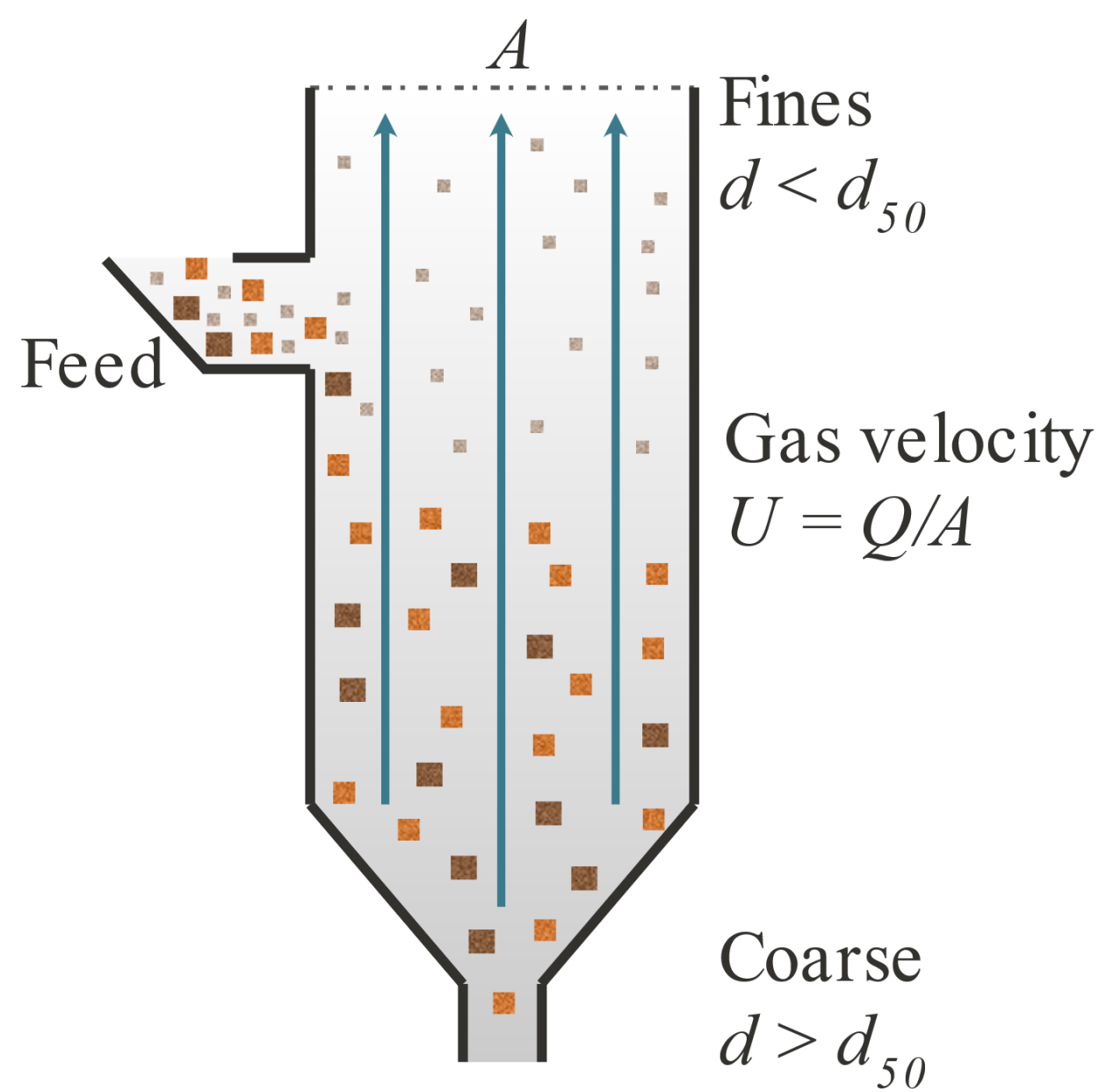
Pneumatic classification

Cut size tuneable,
50–500 μm

Milliwatt power

No compressor

No moving parts



Size classification is the atmosphere's best use in active regolith handling

References

[1] Ganser (1993). *Powder Technology* 77 (2). · [2] Rader (1990). *Journal of Aerosol Science* 21 (2). · [3] Preston et al. (2024). *JGR Planets* 129 (11).



You can check the simulations here!



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