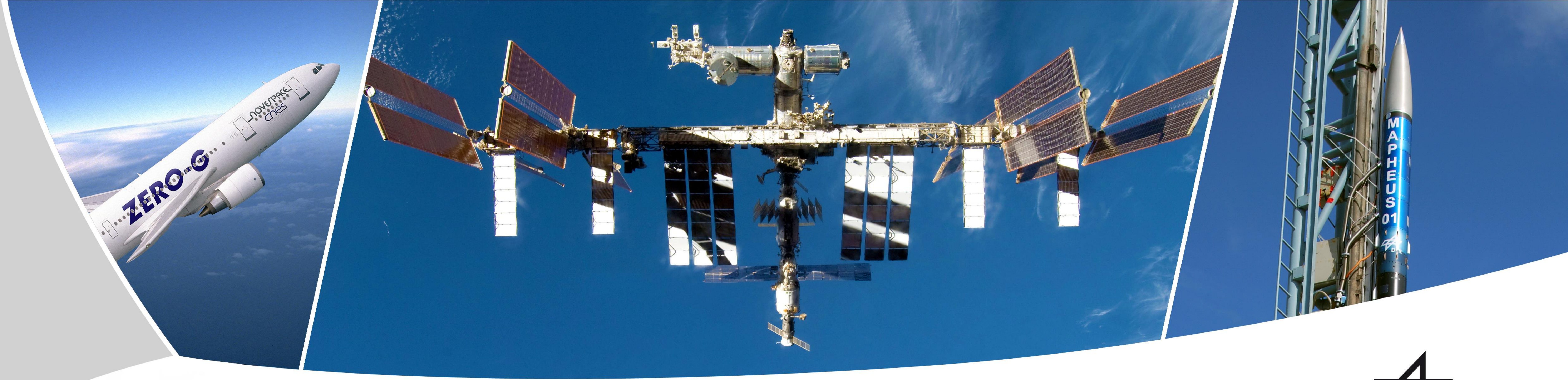

Agitated Granular Media in Microgravity on the International Space Station

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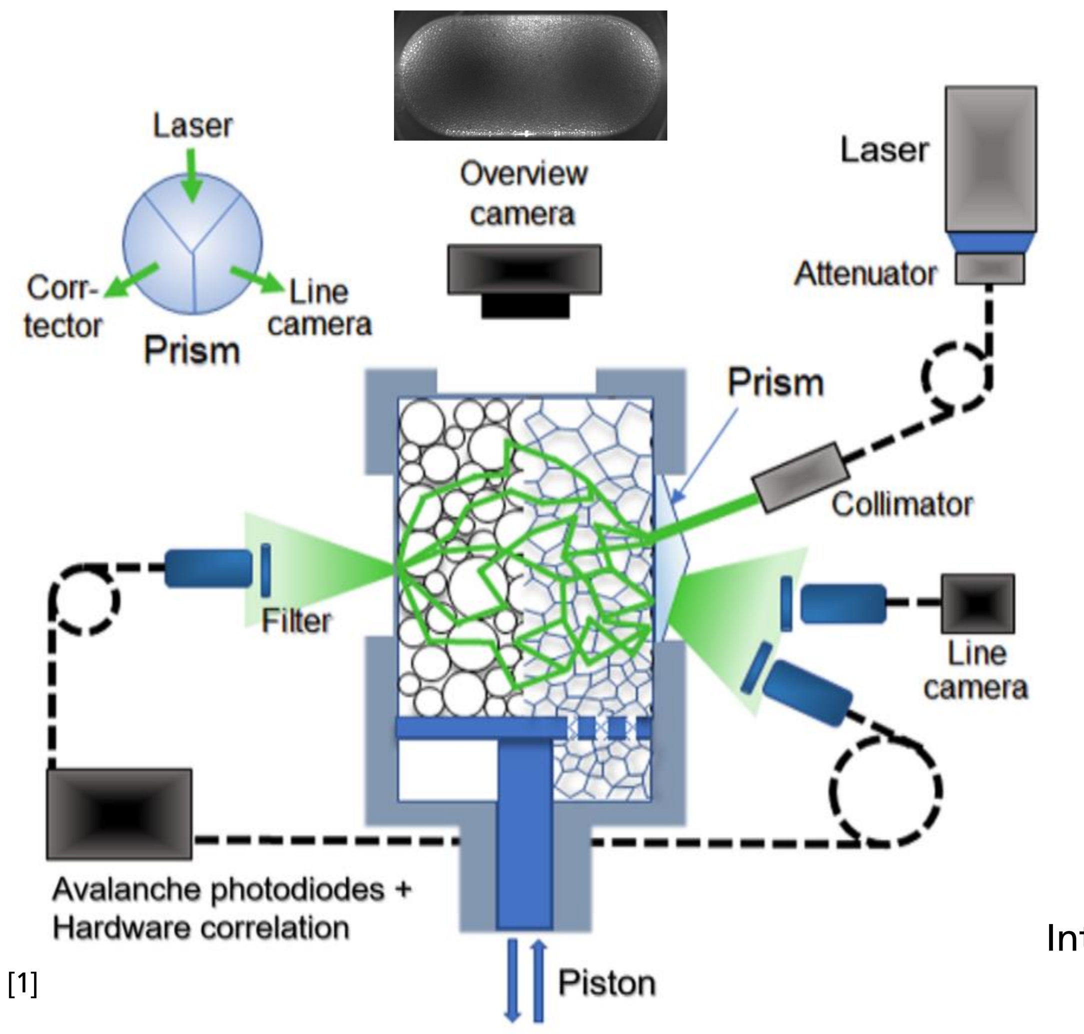
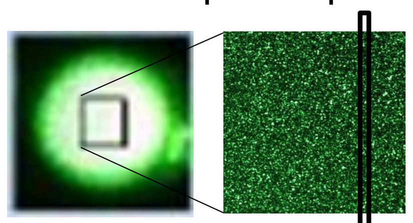
Motivation

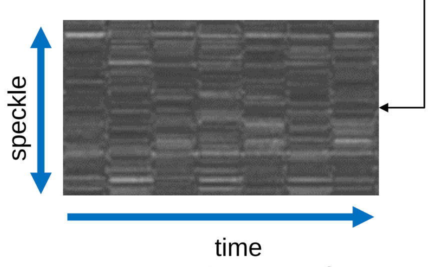
To study the dynamics and jamming of granular media, it would be desirable to treat granular media as an athermal liquid. Therefore, we bring a model granular media system of 140 µm polystyrene spheres on board the ISS into an agitated state without the influence of gravity. The agitated state is created by four piezo crystals which are embedded in the sample container. The microgravity environment seen on the ISS ensures long-lasting steady-state dynamics for hours in less dense states than with gravity.

ISS Ligthscattering Setup

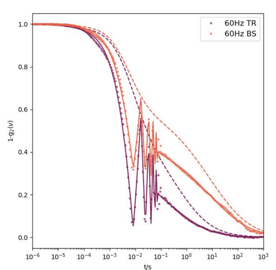


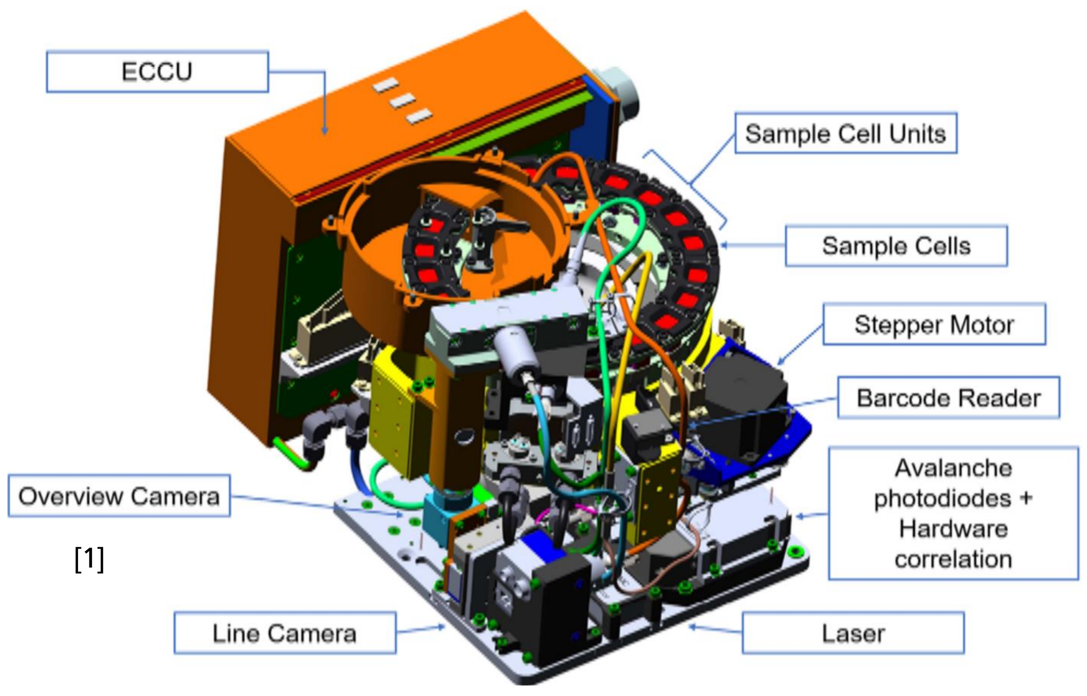
Line camera speckle pettern



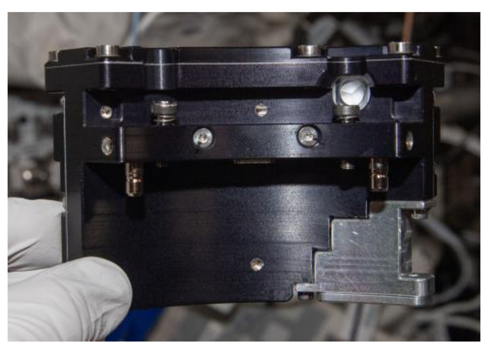


Intensity correlation function





Sample cell on ISS



The granular dynamics is presented in terms of DWS correlation functions obtained with fiber optics in in transmission and backscattering geometry, with an additional line camera detector in the backscattering direction.

Intensity correlation

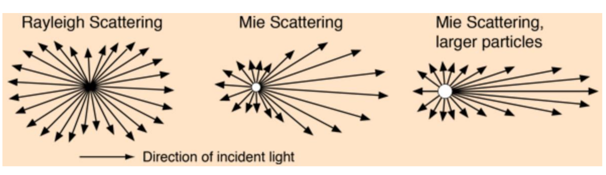
$$g_2(t) = \frac{\langle I(0) \cdot I(t) \rangle}{\langle I \rangle^2}$$

Siegert relation

$$g_2(t) = 1 + \Lambda |g_1(t)|^2$$

Field correlation

$$g_1(t) = \frac{\langle E^*(0) E(t) \rangle}{\langle E^2 \rangle}$$



[2]

Mean squared displacement

$$g_1(t) = \exp\left(-\frac{k_0^2}{3}\left(\frac{L}{l^*}\right)^2 \left\langle \Delta r^2(t) \right\rangle\right)$$

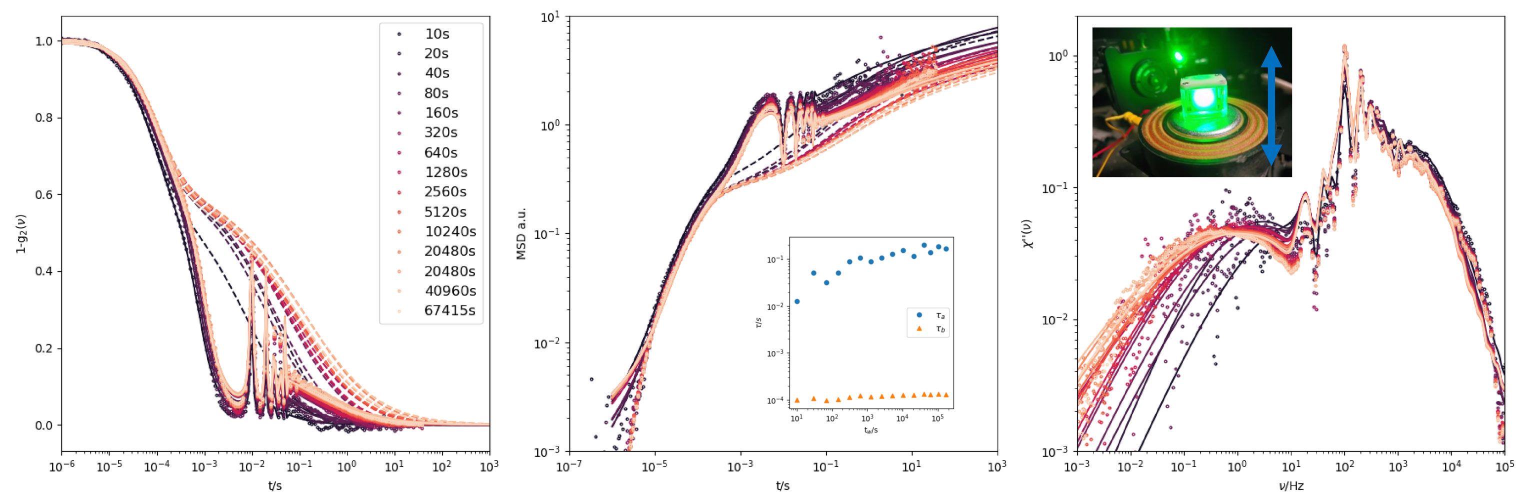
Effective mean free path

$$l^* = \frac{l}{1 - \langle \cos\theta \rangle}$$

Generalized susceptibility

$$\chi''(\omega) \propto \omega \int_0^\infty g_1(t)\cos(\omega t)\, dt$$

Voice Coil Agitation



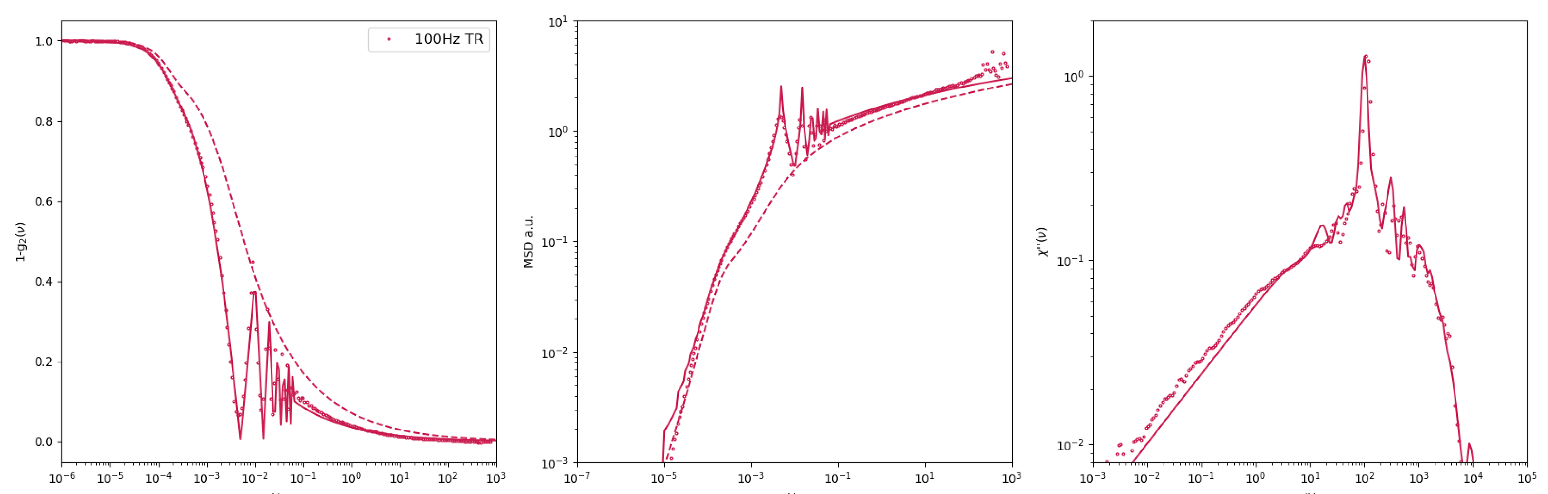
A simple horizontal shaking experiment can be characterized by a oscillation with a relaxation process and a ballistic motion in a cage.

$$g_2(t) - 1 = \exp(-2/3\, k_0^2 (L/l^*)^2 \langle \Delta x^2(t) \rangle) \cdot 1/T \int_0^T \exp(-\kappa^2 A_0^2 [\sin(\omega(t+t_0)) - \sin(\omega t_0)]^2)\, dt_0$$

[3]

Piezo Agitation with Gravity

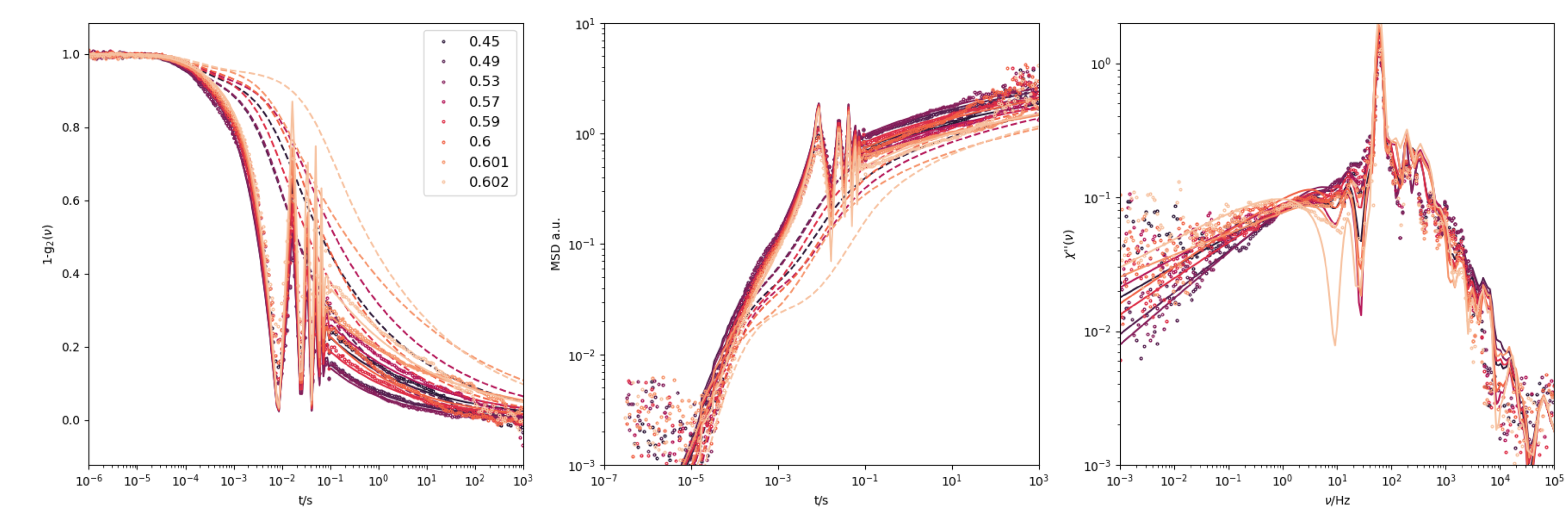
Loose packing – TR (transmission geometry)

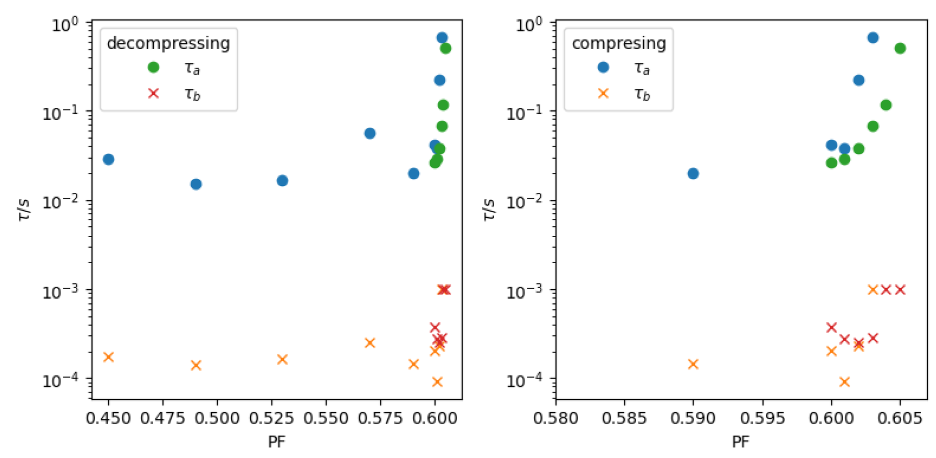


Piezo agitation results in similar correlation features as in voice coil experiment. Agitation oscillations, relaxation and ballistic contributions.

Piezo Agitation in Space

PF dependent – TR





Andreas Mogensen   Jeanette Epps

We present results of the latest CompGran measurement campaign on the ISS, launched in March 2024. Jamming sets in between PF of 0.59 and 0.6. Low packing fractions are possible due to micro gravity.

[1] Born et al., Rev. Sci. Instrum, 92, 2021
[2] Meyer-Arendt, Jurgen R., Introduction to Classical and Modern Optics, 2nd Ed, Prentice-Hall, 1984. 3rd Ed, 1989, 4th Ed
[3] T. Blochowicz: M12 Jamming in granularen Medien, Basic lab Course TU Darmstadt