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Magnetic Janssen Effect

When a granular medium is confined, the pressure at the base of the pile saturates: the walls then support part of the weight of the medium. This phenomenon, known as the Janssen effect (1), arises from frictional interactions between the grains and the walls.

We revisit this effect using ferromagnetic grains. In the presence of a magnetic field, these grains experience anisotropic magnetic interactions. We develop various experimental setups as well as DEM simulations in 2D and 3D to investigate the impact of these magnetic interactions on the Janssen effect, and more generally on the mechanics of such granular packings.

We show that when the magnetic field is aligned with the axis of the tube, the Janssen effect is enhanced compared to the case without a field. Moreover, beyond a critical magnetic field or a critical mass of grains, the apparent mass of the column becomes zero, making it undetectable by the balance (2). We also study the influence of the proportion of magnetic grains in the medium: the pressure at the base of the pile decreases only when the fraction of magnetic grains exceeds a threshold corresponding to the percolation of magnetic clusters (3).

Thus, by tuning the magnetic field and the proportion of magnetic grains, we have an external means of controlling the stress distribution within a granular medium, and thereby modifying its mechanical behavior under confinement.

(1) Janssen, H. A., Investigations of pressure of grain in silos, Zeitschrift des Vereins Deutscher Ingenieure, 39, 1045–1049 (1895).
(2) L. Thorens, K. J. Måløy, M. Bourgoin, S. Santucci, Magnetic Janssen effect, Nature Communications, 12, 2486 (2021).
(3) L. Thorens, S. Rodriguez, N. Taberlet, M. Bourgoin, K. J. Måløy, S. Santucci, Hybrid Magnetic Janssen Effect Arising from Percolating Ferromagnetic Grain Networks, submitted (2026).