Influence of active Brownian particle ensembe size on collective phenomena in a colloidal plasma

Mizeva K. A.[1,2,@], **Koss X. G.**[1,2], **Zamorin D. A.**[1,2], **Vasiliev M. M.**[1] **and Petrov O. F.**[1,2]

[1] Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg˜2, Moscow, 125412, Russia
[2] Moscow Institute of Physics and Technology, Institutskiy Pereulok 9, Dolgoprudny, Moscow Region, 141701, Russia

[@] mizeva.ka@phystech.edu

Several recent studies have investigated mesoscopic systems of active particles [1–3]. However, questions concerning their structural transitions, energy transformation, and evolution under various external conditions remain open. In this work, finite systems of active particles were studied experimentally in an RF discharge. A voltage with a frequency of 13.56 MHz was applied to the parabolic electrode; then, melamine-formaldehyde particles, fully coated with copper, were introduced into the discharge. Charged by electron and ion fluxes, the particles levitated above the electrode center and were illuminated by a laser. The laser power was varied from 0.1 W to 1.2 W, and the ensemble size ranged from 3 to ∼900 particles.
As the laser intensity increased, the mean kinetic energy and localization radius increased, while the fractal dimension of particle trajectories approached unity. Clusters containing several hundred particles differed qualitatively from those containing fewer than 100 particles, exhibiting a larger localization radius and a nonmonotonic dependence of mean kinetic energy on cluster size. No shell-by-shell melting was detected, and a more ordered state, as assessed by the effective coupling parameter, was observed only in clusters containing 19–97 particles.

[1] Koss X G, Petrov O F, Statsenko K B and Vasiliev M M 2018 *EPL* **124**
[2] Vasiliev M M, Alekseevskaya A A, Koss X G, Vasilieva E N and Petrov O F 2005 *High Temp* **61** 759–763
[3] Melzer A, Marder T, Schütt S, Boltz H H, Ihle T, Knapek C A, Maier D and Mohr D P 2025 *Physics of Plasmas* **32** 123702