On energy and clusters in stochastic systems of sticky gravitating particles

Abstract

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We consider one-dimensional model of gravitational gas which consists of n particles with random initial coordinates and initial speeds. Particles begin to move under the influence of forces of mutual attraction. While colliding, particles stick together forming a new particle ("cluster") which characteristics are defined by the laws of mass and momentum conservation.

In the terms of probability theory we study the gas' properties as $n \to \infty$. In the case of zero initial speeds ("cold gas") we study the asymptotic behavior of number of clusters $K_n(t)$: for every $t \geq 0$ holds $\frac{K_n(t)}{n} \xrightarrow{P} f(t)$ as $n \to \infty$, where $f(t)$ is a deterministic function.

We also explore kinetic energy of the gas $E_n(t)$. In the case of non-zero initial speeds ("warm gas") it's proved that the gas instantly "cools", i. e. $E_n(t) \xrightarrow{P} 0$ as $(t, n) \to (+0, \infty)$. Moreover, in the both cases of cold and warm gas at any instant $t \in (0, 1)$ holds $E_n(t) \xrightarrow{P} \frac{t^2}{6}$ as $n \to \infty$.

Various limit properties of the gas are analyzed in [1]-[4]:

[1] Martin Ph.A., Piasecki J. (1996) *Aggregation dynamics in a self-gravitating one-dimensional gas. – J. Statist. Phys.*, **84**, *837-857*.

[2] Giraud C. (2001) *Clustering in a self-gravitating one-dimensional gas at zero temperature. – J. Statist. Phys.*, **105**, *585-604.*

[3] Lifshits M., Shi Z. (2003) *Aggregation rates in one-dimensional stochastic systems with adhesion and gravitation. Preprint (www.arxiv.org, Physics, Condensed Matter, paper 0311025)*

[4] Bonvin J.C., Martin Ph.A., Piasecki J. and Zotos X. (1998) *Statistics of mass aggregation in a self-gravitating one-dimensional gas. – J. Statist. Phys.*, **91**, *177-197.*