Лекция 7

Диффузия микрочастиц в пылевой плазме

Evolution function of mass transfer (2D)

$$D_{msd}(t) = \left\langle \vec{r}(0) - \vec{r}(t) \right\rangle^2 / 4t$$

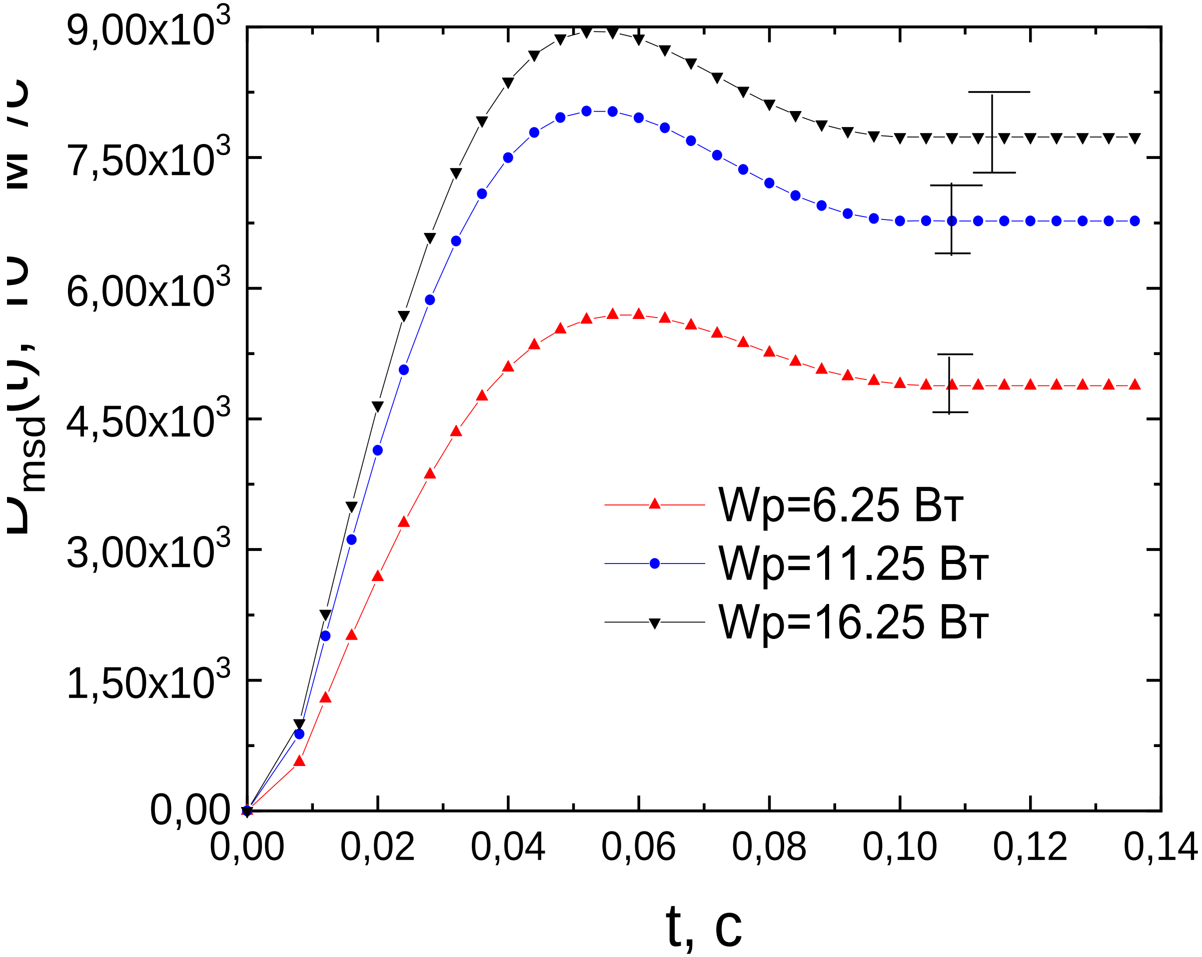
Коэффициент диффузии

$$D_{msd} = \lim_{t \to \infty} D_{msd}(t)$$

Для невзаимодействующих частиц

$$D_0 = \frac{k_B T_d}{\nu m_d}$$

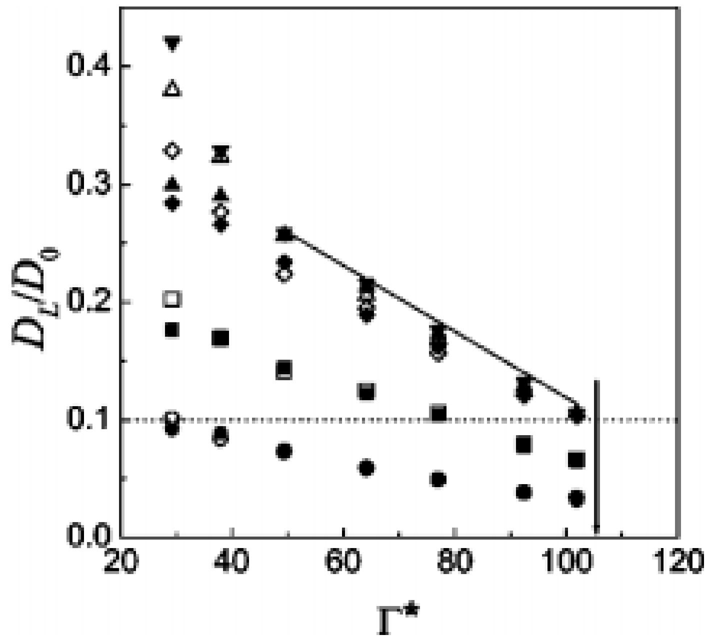
ν - коэффициент трения, возникающего, когда пылинки движутся в плазме.



Временная зависимость отношения среднеквадратичного смещения к времени наблюдения

Таблица 1 - Температура и коэффициент диффузии пылевых частиц при постоянном давлении и при различных значениях мощности разряда

Wp (W)	$k_B T_d$ (eV)	D_0, $cm^2/\sec$	D_{mod}, $cm^2/\sec$	D_{mod}/D_0
6.25	0.41	$0.68 \cdot 10^{-4}$	$0.48 \cdot 10^{-4}$	0.70
11.25	0.66	$1.10 \cdot 10^{-4}$	$0.66 \cdot 10^{-4}$	0.60
16.25	0.94	$1.56 \cdot 10^{-4}$	$0.77 \cdot 10^{-4}$	0.49



Vaulina O.S., Khrapak S. and Morfill G.E. Universal scaling in complex (dusty) plasmas // Phys. Rev. E. – 2002. – Vol. 66. - P. 016 404.

FIG. 4. The ratio D_L/D_0 for strongly interacting Yukawa systems as a function of the modified coupling parameter Γ^* for different values of θ. Solid symbols correspond to $\kappa=2.42$ while open symbols correspond to $\kappa=4.84$. The values of the dynamical parameter are $\theta=0.044$ (circles), 0.13 (squares), 0.4 (diamonds), 1.2 (triangles), 3.6 (inverted triangles) [only shown for $\kappa=2.42$]. The solid line denotes a simple linear approximation of the numerical data in the limit of large θ (see text). The dotted line corresponds to $D_L/D_0=0.1$. The arrow at $\Gamma^*=105.5$ marks the point at which the diffusion coefficient has decreased abruptly.

Self-diffusion in two-dimensional quasimagnetized rotating dusty plasmas

P. Hartmann,[1,2] J. C. Reyes,[2] E. G. Kostadinova,[2] L. S. Matthews,[2] T. W. Hyde,[2] R. U. Masheyeva,[3] K. N. Dzhumagulova,[3] T. S. Ramazanov,[3] T. Ott,[4] H. Kählert,[4] M. Bonitz,[4] I. Korolov,[1] and Z. Donkó[1]

However, in performing real experiments or numerical simulations, the systems of interest may behave slightly differently from the Brownian motion model and can have nonlinear time dependencies, for example MSD $\propto t^{\alpha}$, where the exponent α is a dimensionless parameter usually with a value close to unity. The case when $\alpha > 1$ is called superdiffusion, and the opposite case $\alpha < 1$ is called subdiffusion. In both cases Eq. (2) is inconclusive and it is not possible to characterize the particle transport with a single parameter. Alternatively, it is possible to extend the concept of the diffusion coefficient to two parameters, namely the exponent α introduced previously and the generalized diffusion coefficient:

$$D_{\alpha} = \lim_{t\to\infty} \frac{\mathrm{MSD}}{4t^{\alpha}}, \tag{3}$$

as discussed in [12].

The topic of anomalous diffusion in general is of high interest in various fields in physics and biology [29], where particle simulation methods provide significant contributions to the quantification of particle transport [30] because a solid theoretical background is still not available, especially in low dimensions [31]. Some predictions suggest that in the real thermodynamic limit (infinite system size and observation time) in isotropic systems with short range interparticle interactions, the diffusion becomes normal and the instantaneous value of the diffusion exponent α asymptotically approaches unity [32]. However, for finite sizes and short times, highly relevant for nanotechnology and high frequency applications, the system can show significant anomalous transport, which can even be enhanced by the external magnetic field [19,33–35].