Dust particle statistical properties in a glass box

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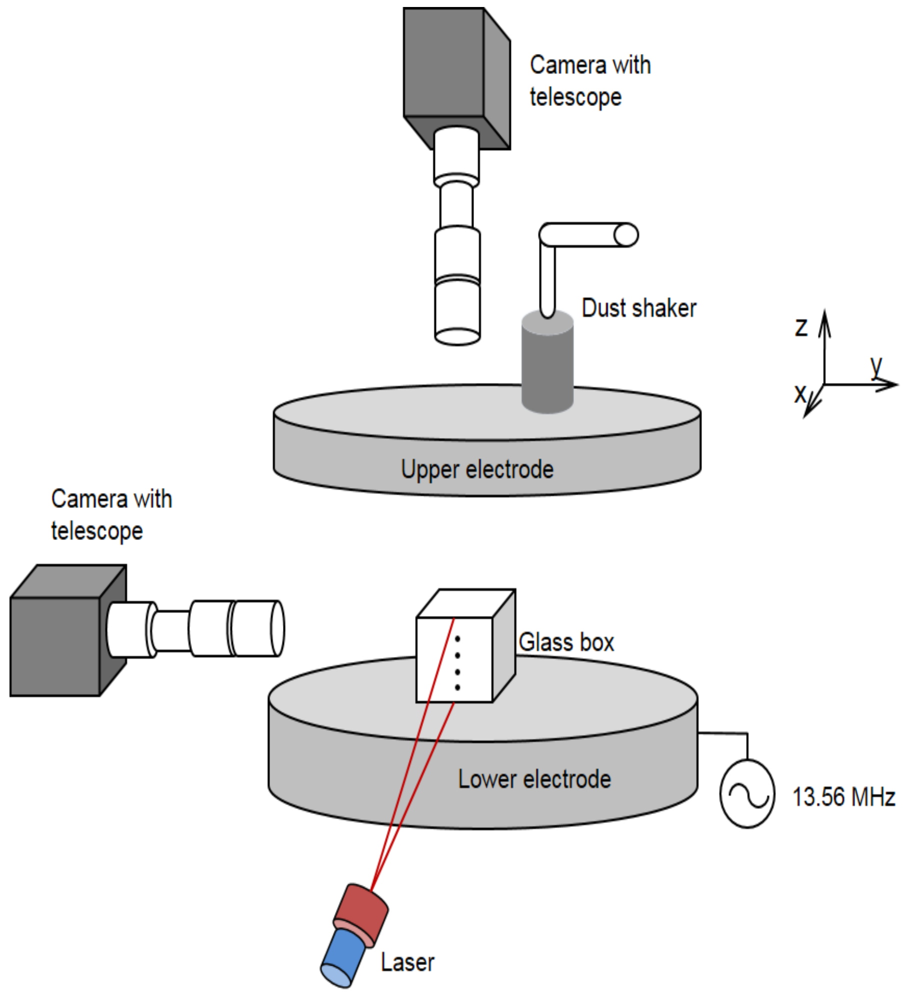
Outline

- Introduction
- Experiment
- Discussion
- Summary



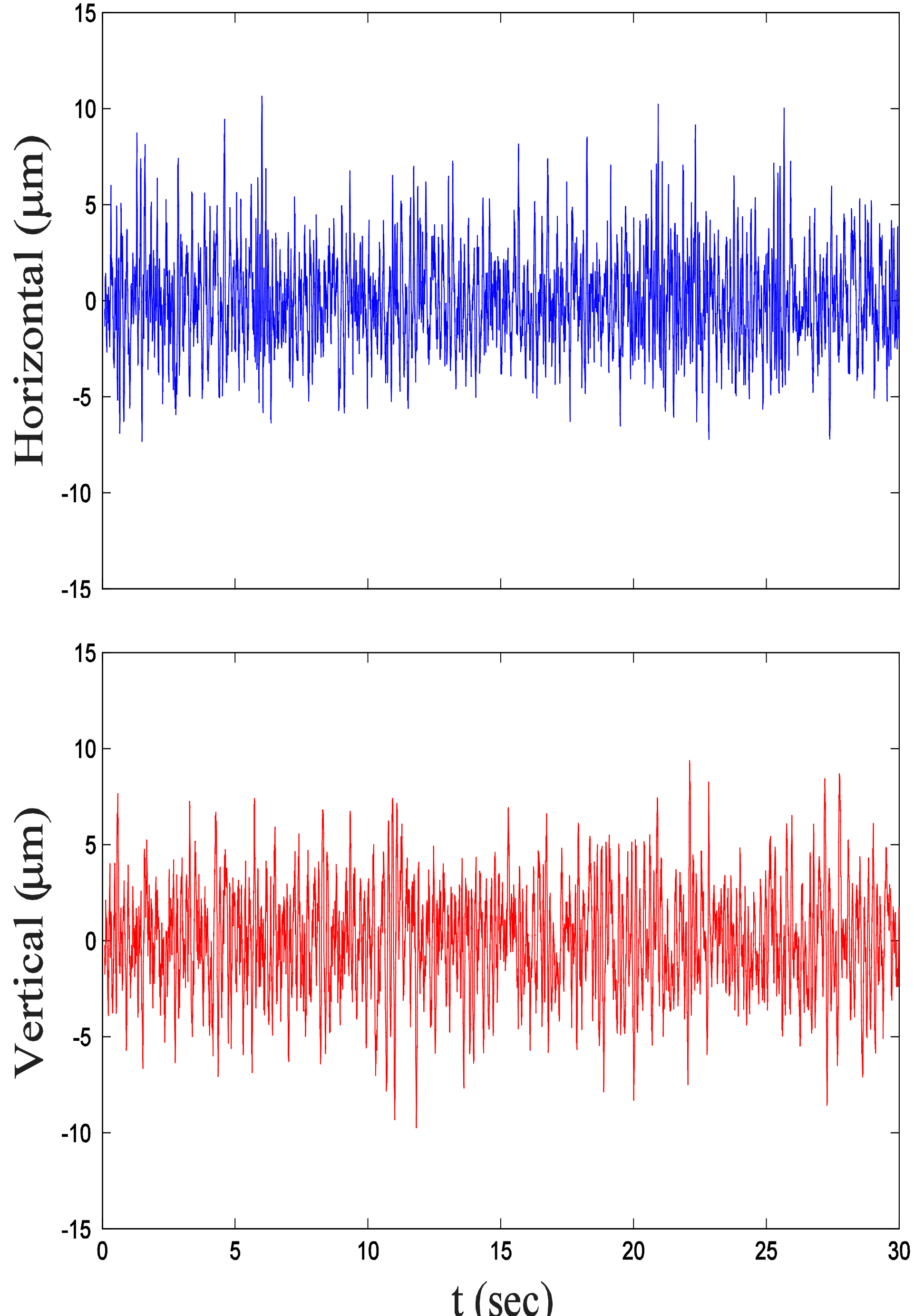
Introduction

1. Fluctuations, dust Brownian motion
2. Gaussian velocity distribution
3. Langevin equation
4. Mean square displacement (MSD)

Introduction

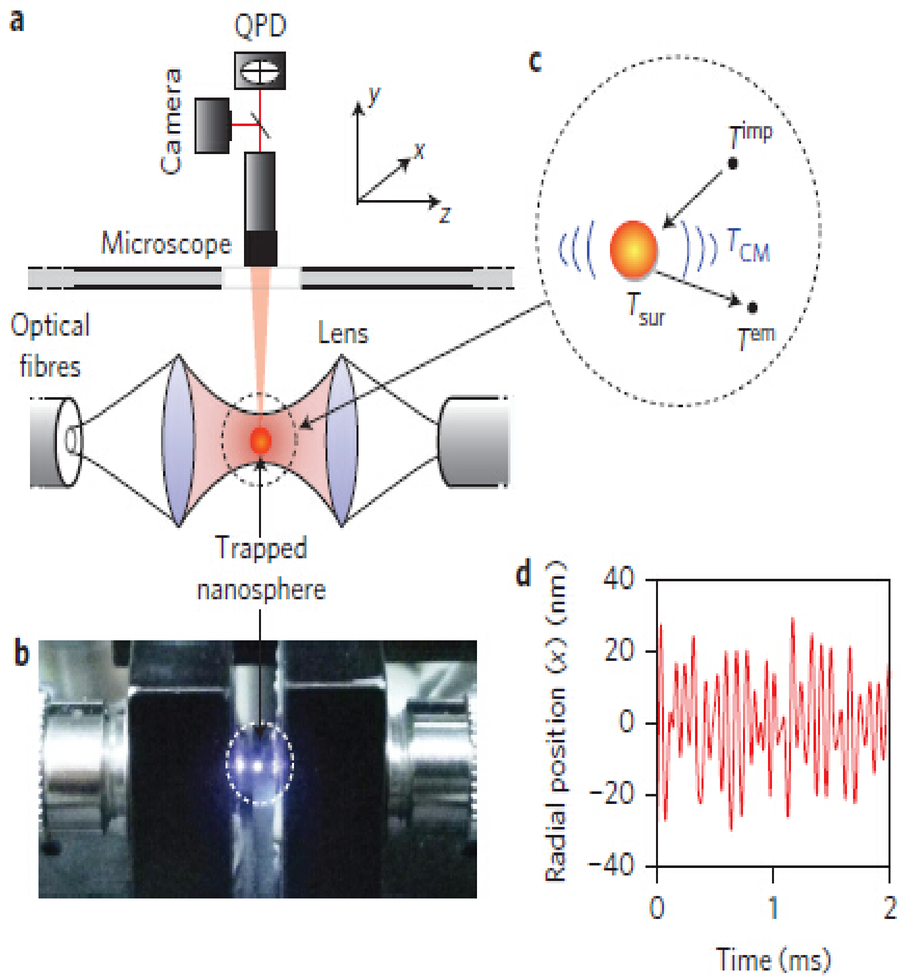
1. Fluctuations

A single dust particle confined in a glass box in the GEC cell



Introduction

1. Fluctuations

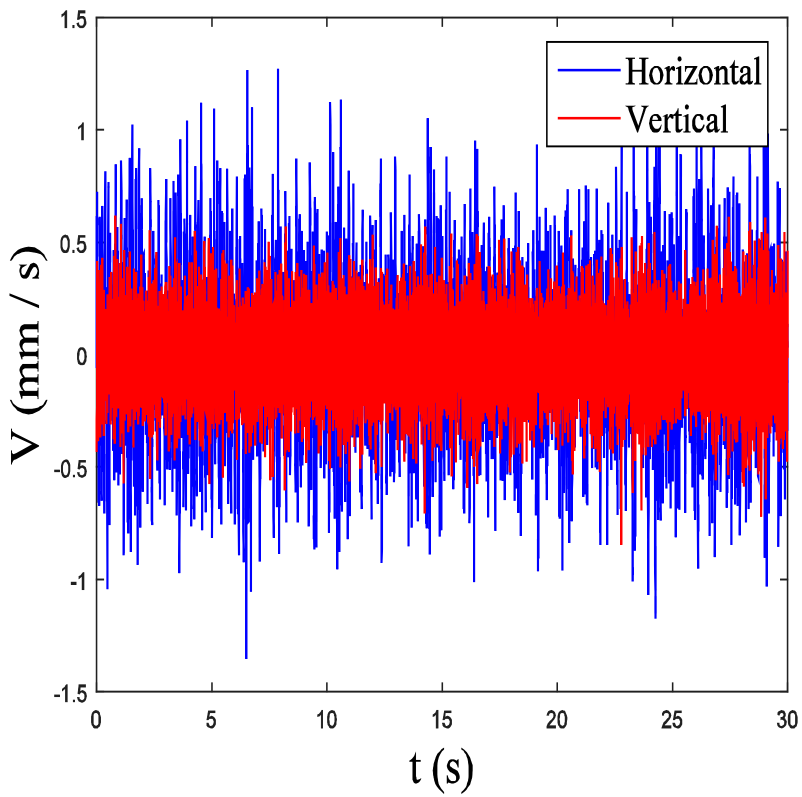


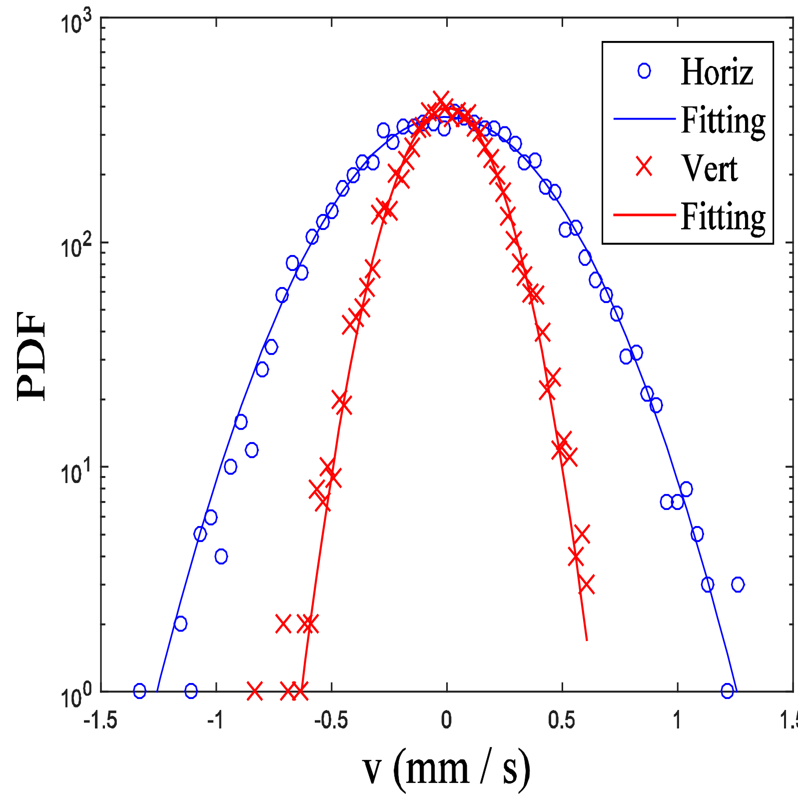
J. Millen, T. Deesuwan, P. Barker and J. Anders, *Nature Nanotechnology*, 9, 425, 2014

Introduction

2. Gaussian velocity distribution

$$k_B T_d = \frac{1}{2} m_d V^2$$



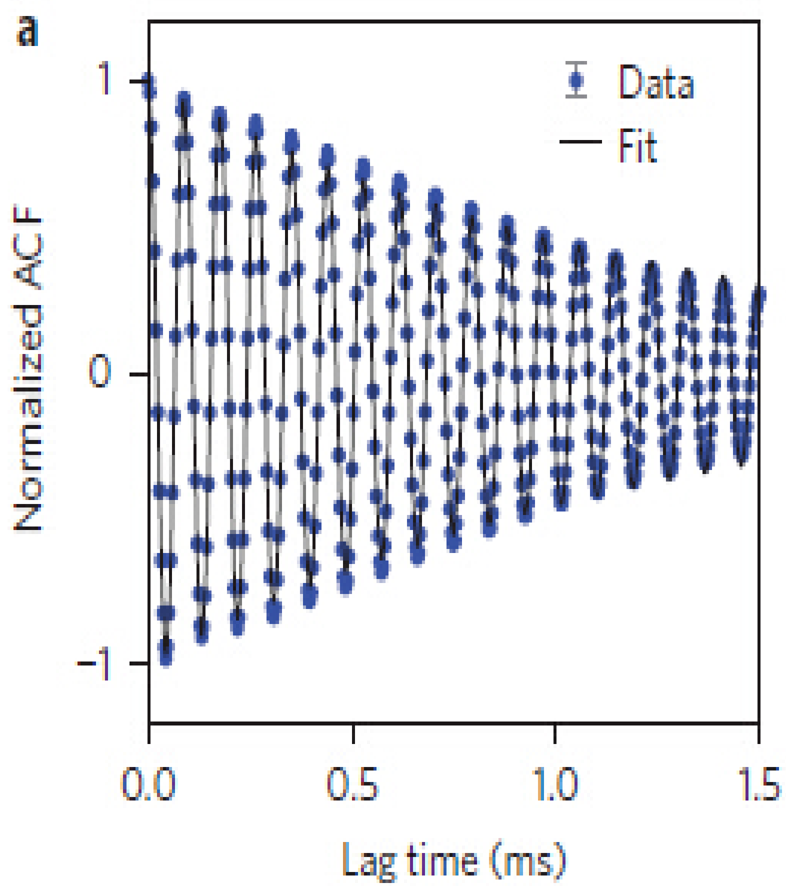


Introduction

3. Langevin equation

$$m_d\ddot{x}(t) = -m_d\gamma\dot{x} - \frac{\partial V}{\partial x} + R(t)$$

$$R(\tau) = \langle x(t+\tau)x(t)\rangle = 2G\delta(\tau)$$



J. Millen, T. Deesuwan, P. Barker and J. Anders, *Nature Nanotechnology*, 9, 425, 2014

Introduction

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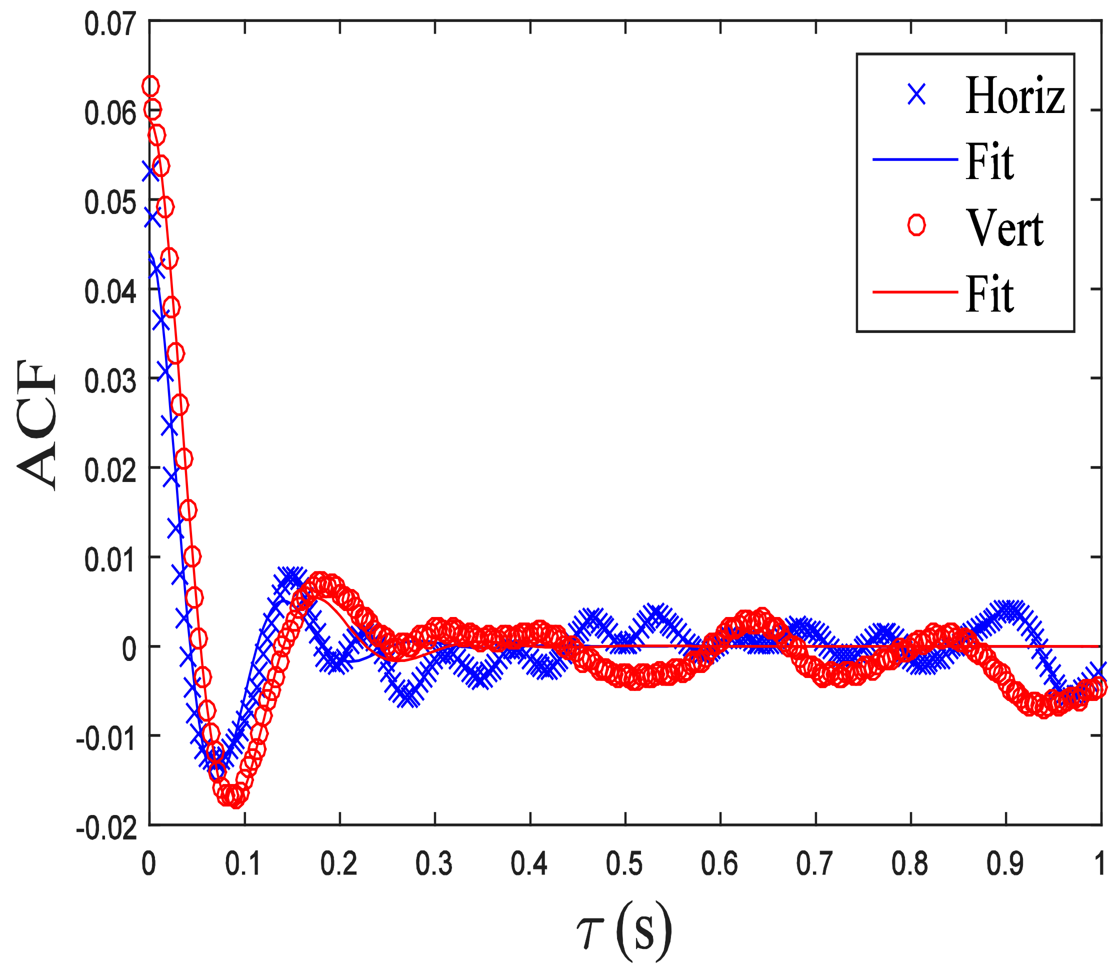
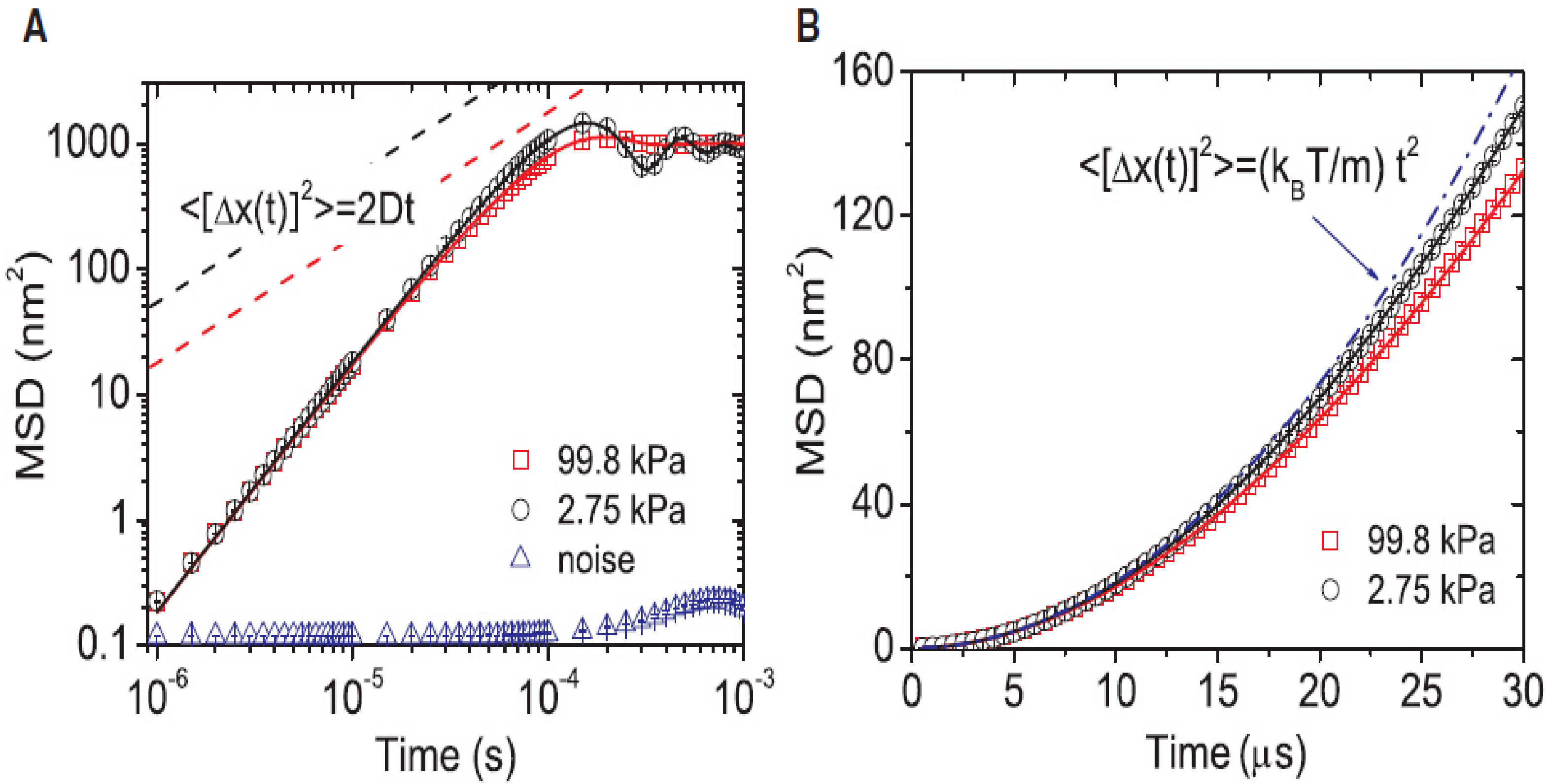


Introduction

4. Mean square displacement (MSD)

$$\left\langle \left[\Delta \left(x(t) \right) \right]^2 \right\rangle = 2Dt \qquad (t >> \tau_p)$$

$$\left\langle \left[\Delta \left(x(t) \right) \right]^2 \right\rangle = v^2 t^2 = \left(k_B T / m_d \right) t^2 \qquad (t << \tau_p)$$



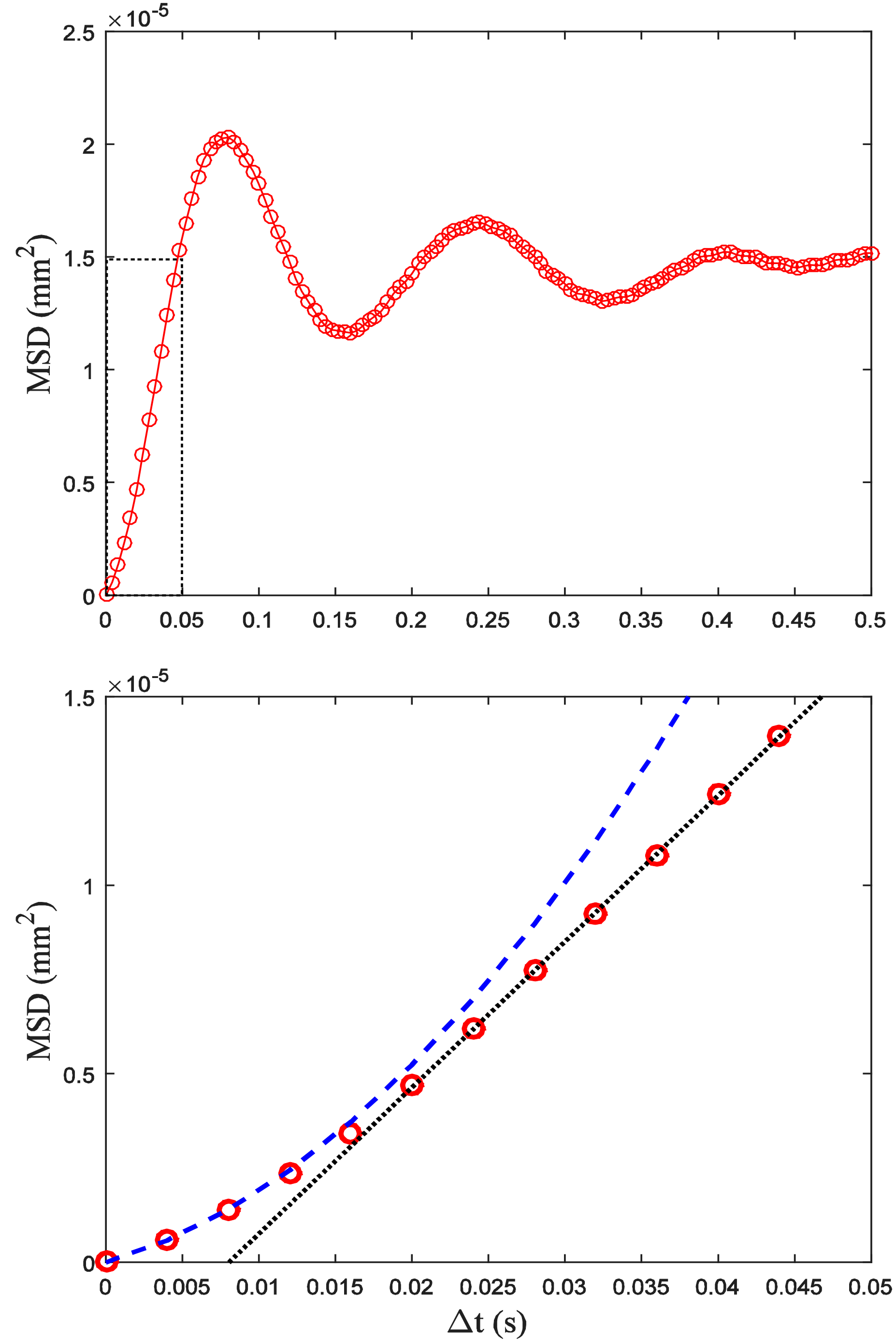
Tongcang Li, Simon Kheifets, David Medellin, Mark G. Raizen, *Science*, 328, 1673, 2010

Introduction

4. Mean square displacement

$$\left\langle \left[\Delta\left(x(t)\right)\right]^2 \right\rangle = 2Dt \qquad (t \gg \tau_p)$$

$$\left\langle \left[\Delta\left(x(t)\right)\right]^2 \right\rangle = v^2t^2 = \left(k_BT/m_d\right)t^2 \qquad (t \ll \tau_p)$$



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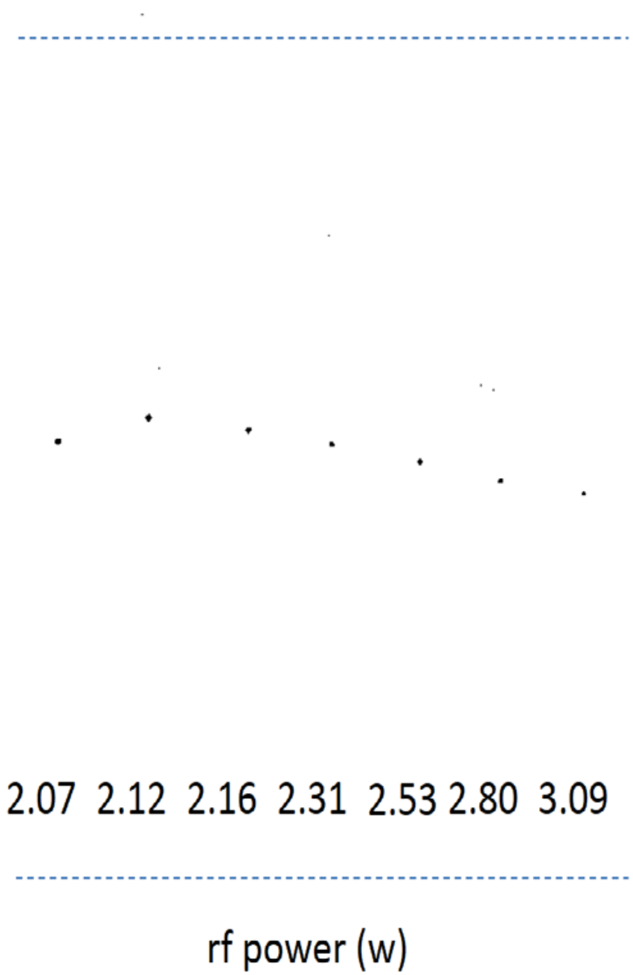
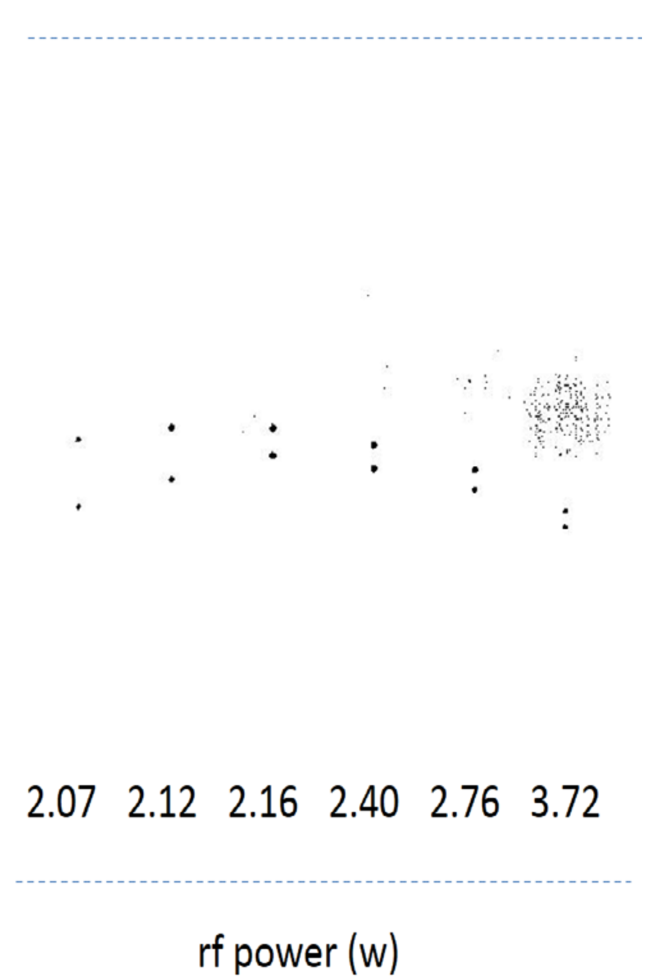
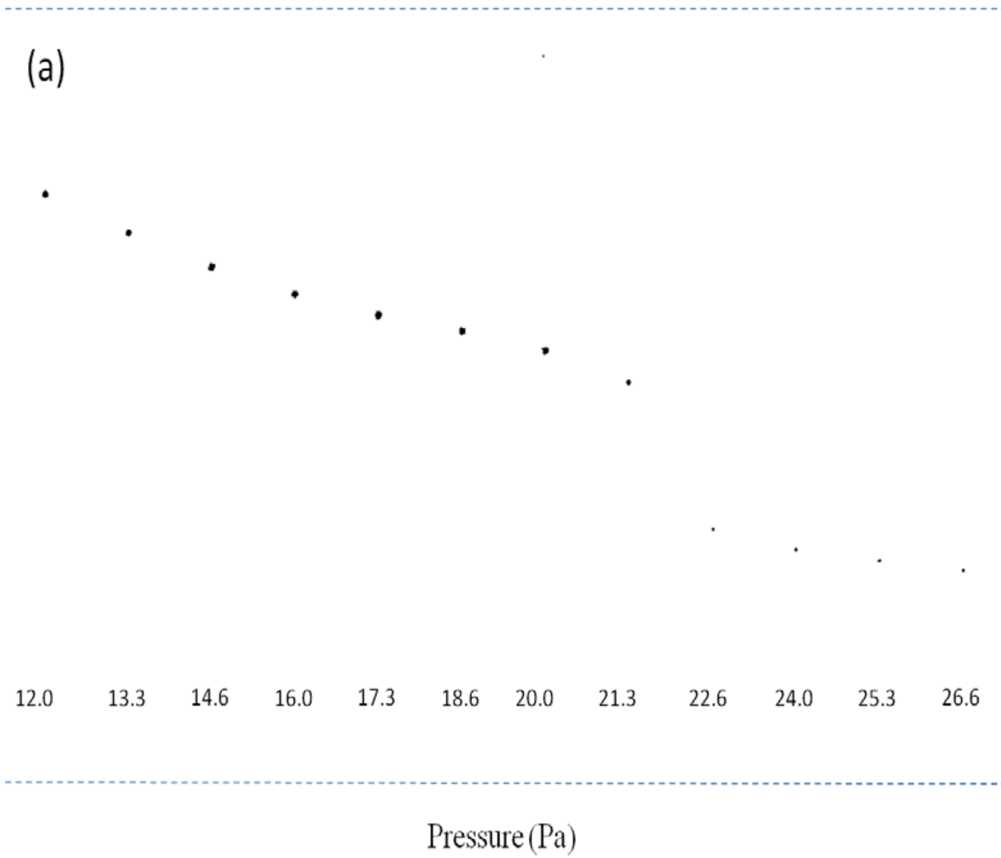
Experiment

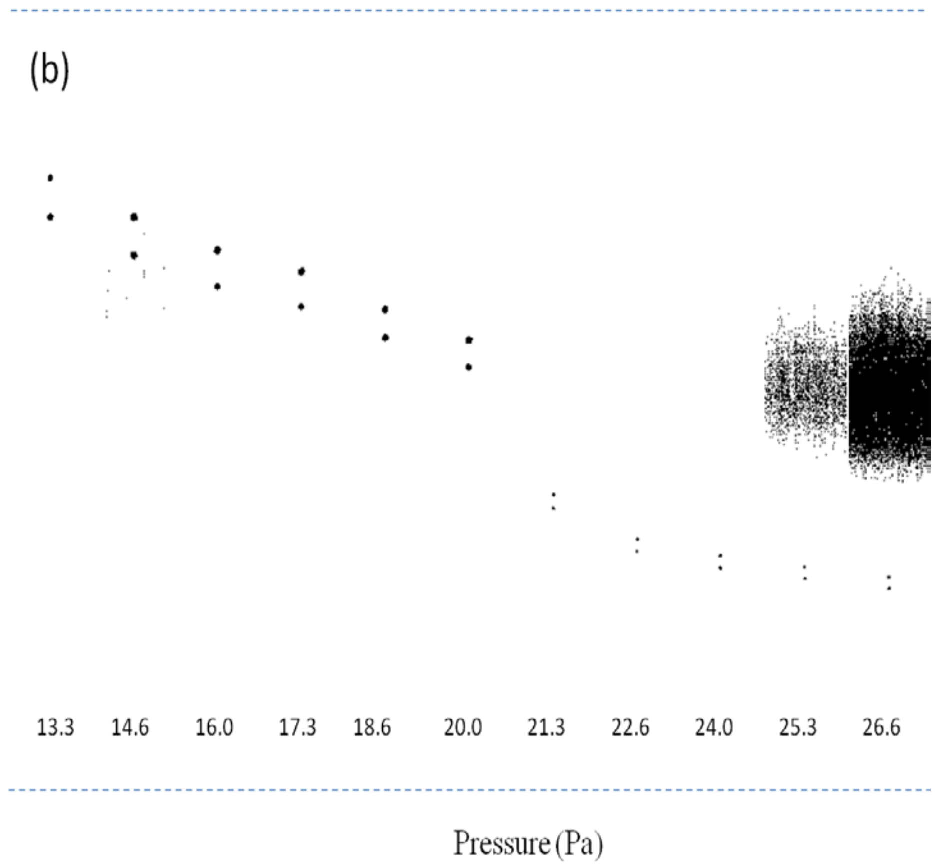




Particle levitation position as a function of rf power at fixed pressure(20 Pa)

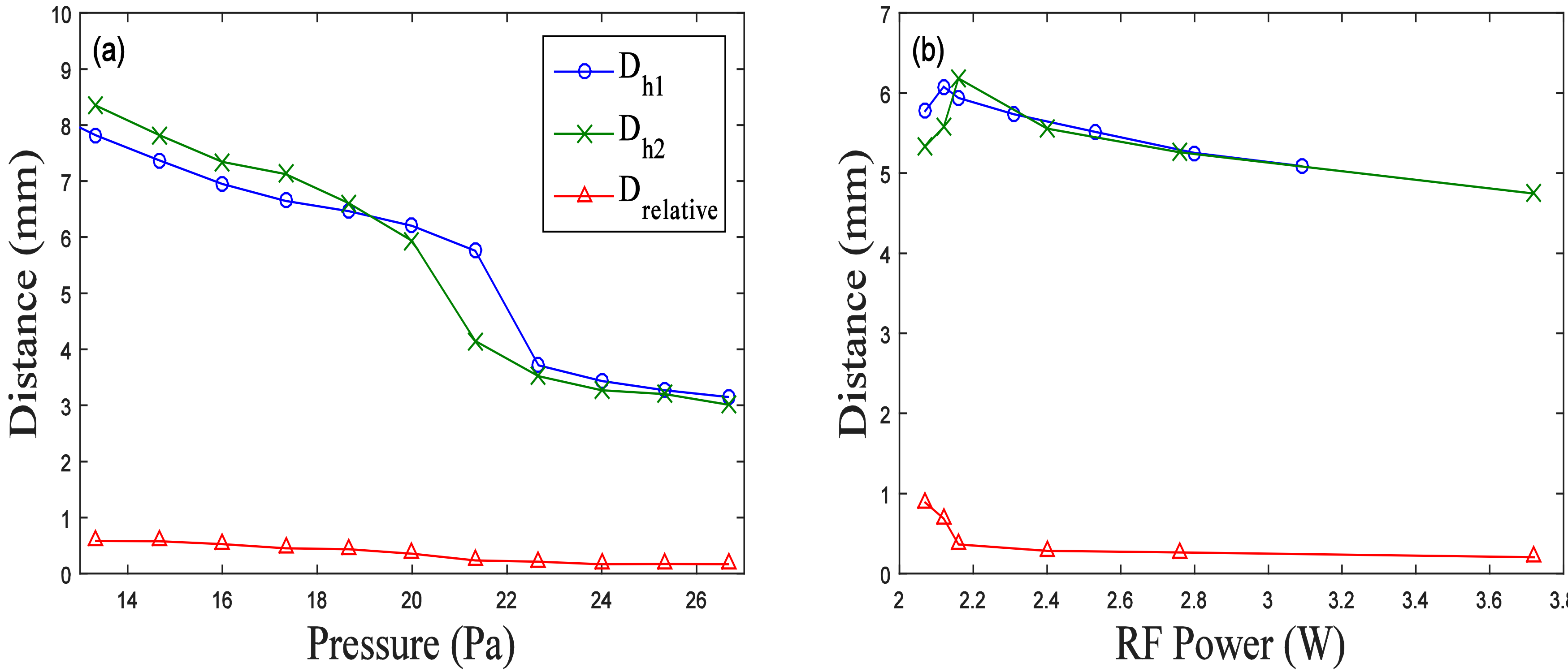
Experiment





Particle levitation position as a function of the pressure at fixed rf power (2.10 W)

Experiment



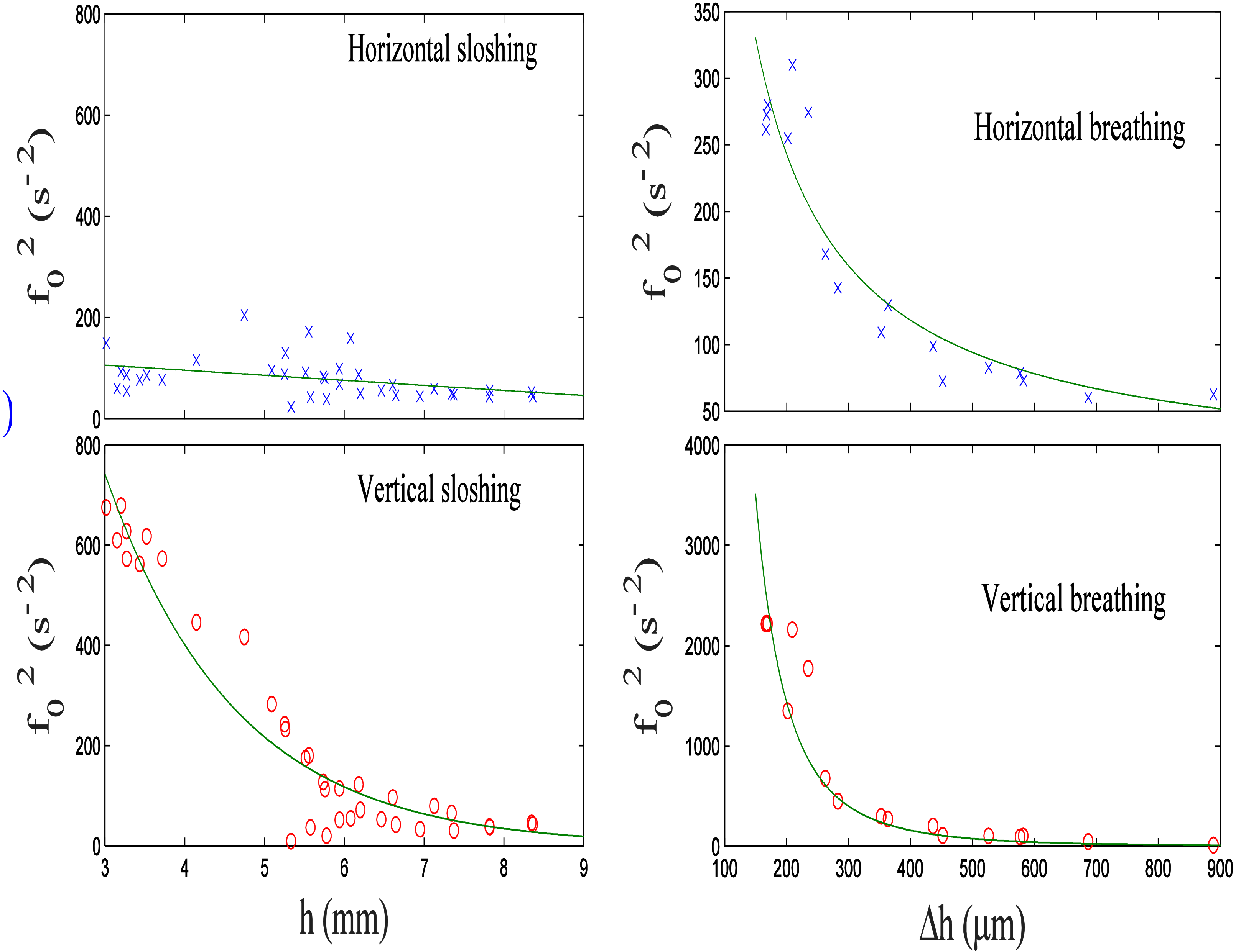
Combined single- and two- particle levitation height (a) as a function of pressure, (b) as a function of rf power

Experiment

$$m_d \ddot{x}(t) =$$

$$-m_d \gamma \dot{x} - \frac{\partial V}{\partial x} + R(t)$$

$$m_d \omega_0^2 x = \frac{\partial V}{\partial x}$$



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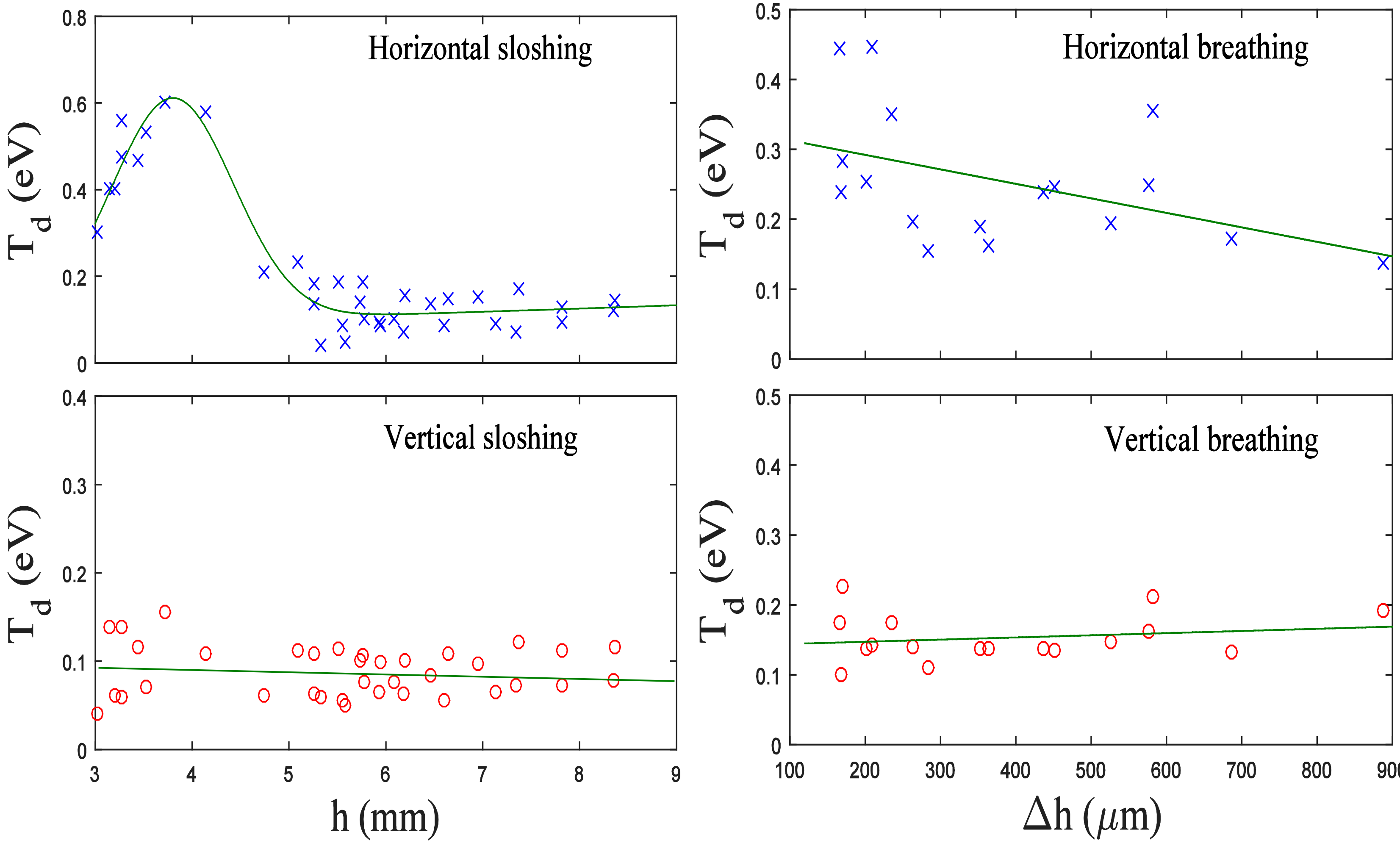
Experiment

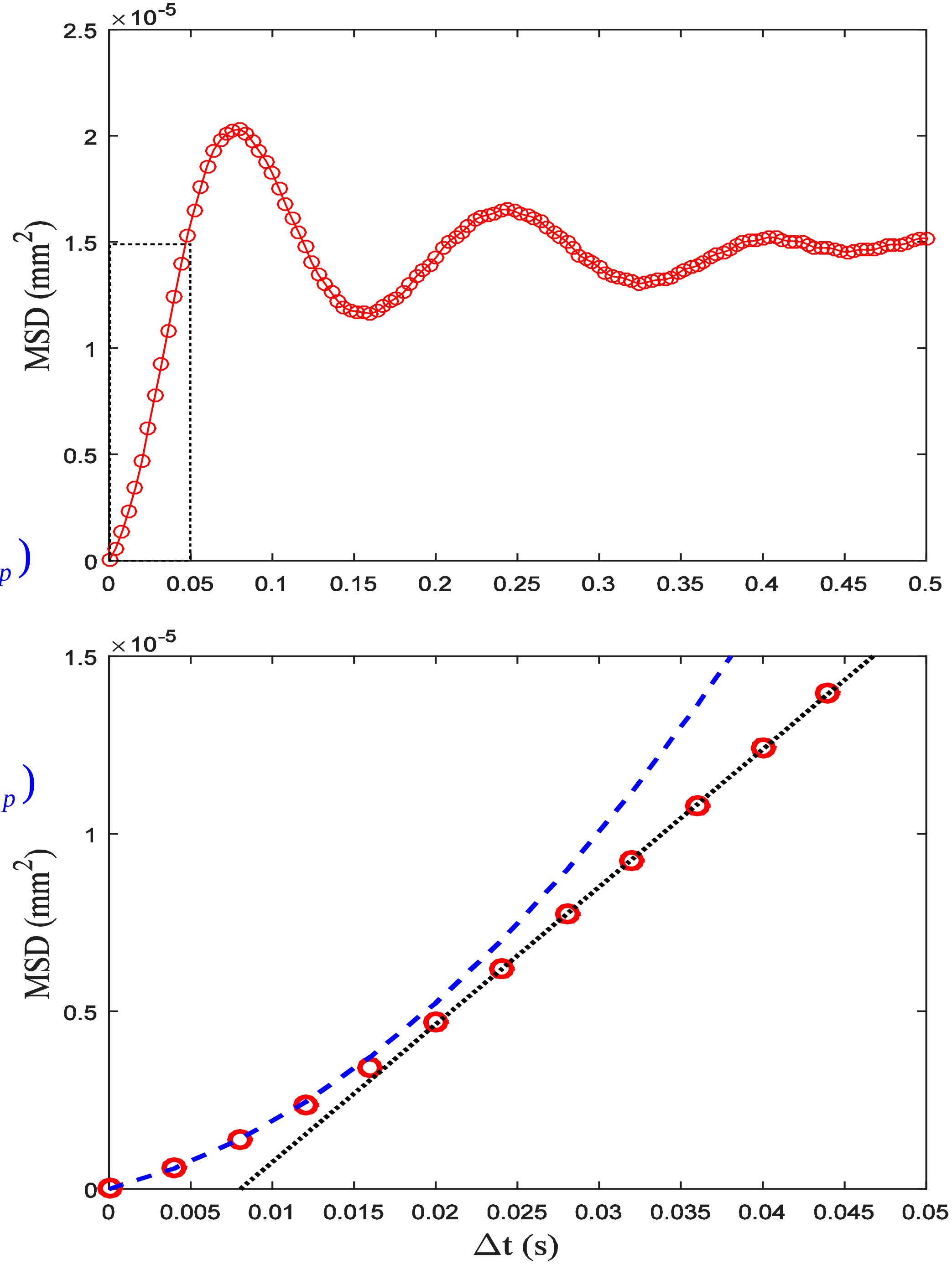
$$k_B T_d = \frac{1}{2} m_d \sigma^2$$



Experiment

$$\left\langle \left[\Delta\left(x(t)\right)\right]^2 \right\rangle = 2Dt \qquad (t >> \tau_p)$$

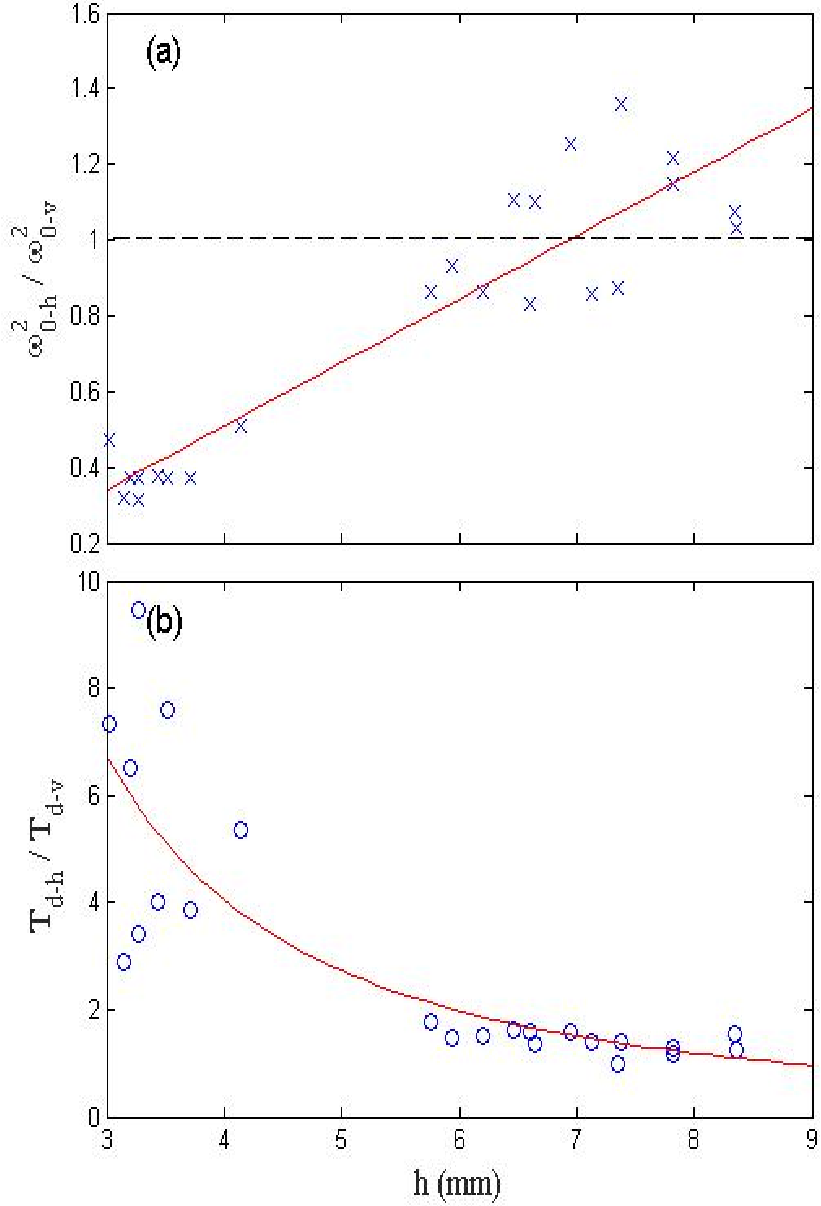
$$\left\langle \left[\Delta\left(x(t)\right)\right]^2 \right\rangle = v^2t^2 = \left(k_BT/m_d\right)t^2 \qquad (t << \tau_p)$$



Discussio

$$m_d \omega_0^2 x = \frac{\partial V}{\partial x}$$

$$k_B T_d = \frac{1}{2} m_d \sigma^2$$



The resonance frequency square ratio of horizontal over vertical represents the confinement strength ratio.

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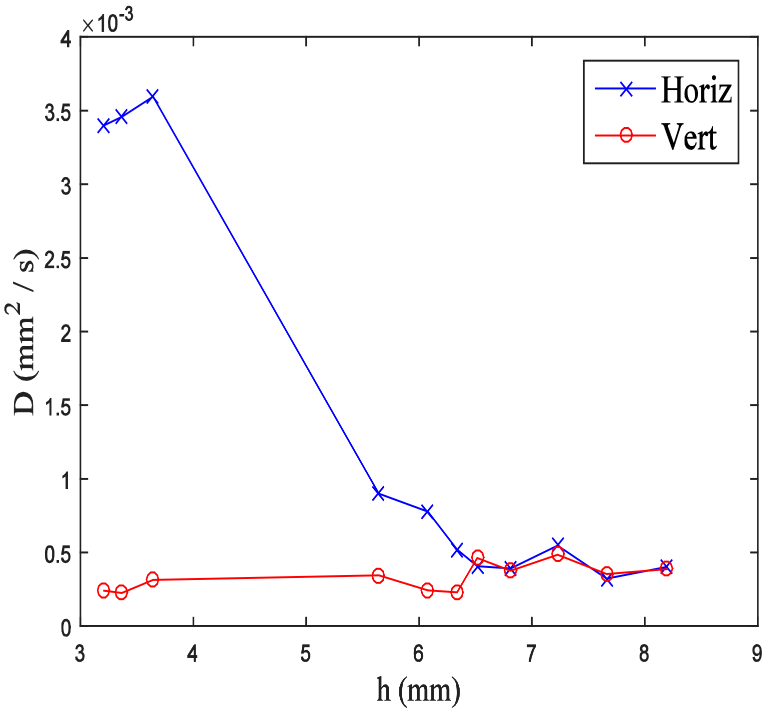
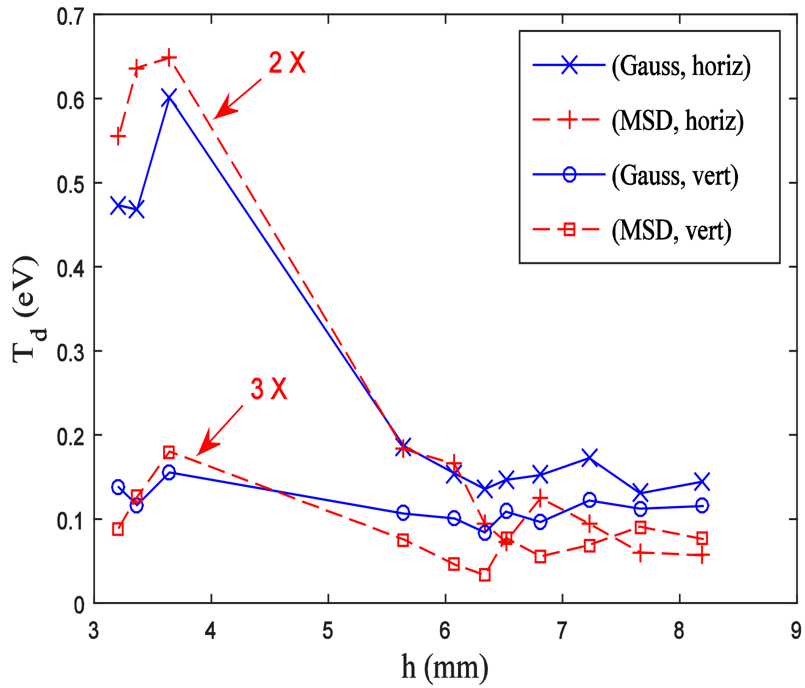
Discussion





Diffusion constant and particle temperature as a function of the levitation height. The levitation height change is caused by the pressure, from 12 Pa to 26 Pa. The measured D and Td are hindered by some effect, need more investigations

Summary and future work

- Information of the plasma diagnostics can be extracted by using classical statistical techniques on the dust particle fluctuations.
- Using the techniques to investigate the structural changes of vertical dust chains in a glass box.

Thank you very much