

Equipartition Force Calibration

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(Brownian Motion)

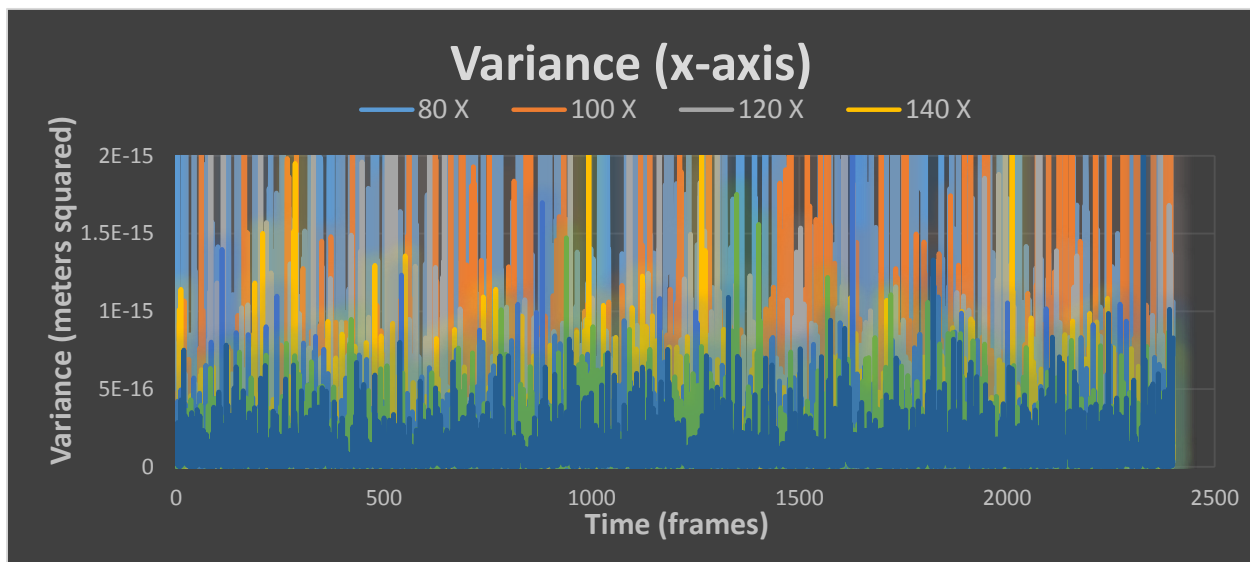
This force calibration relates the thermal kinetic energy known from the equipartition theorem to a theoretical spring restoring force keeping the particle in the center of the trap.

$$\frac{1}{2} k_B T = \frac{1}{2} k \langle x^2 \rangle$$

Remember, this equation is valid for only ONE direction of freedom at a time ($\langle x^2 \rangle$ variance refers to only one direction, not an absolute distance from the center of the trap).

The variance $\langle x^2 \rangle$ is the average of the squared differences between the particle's position and the equilibrium position (average position), $\sum_i (x_{avg} - x_i)^2$.

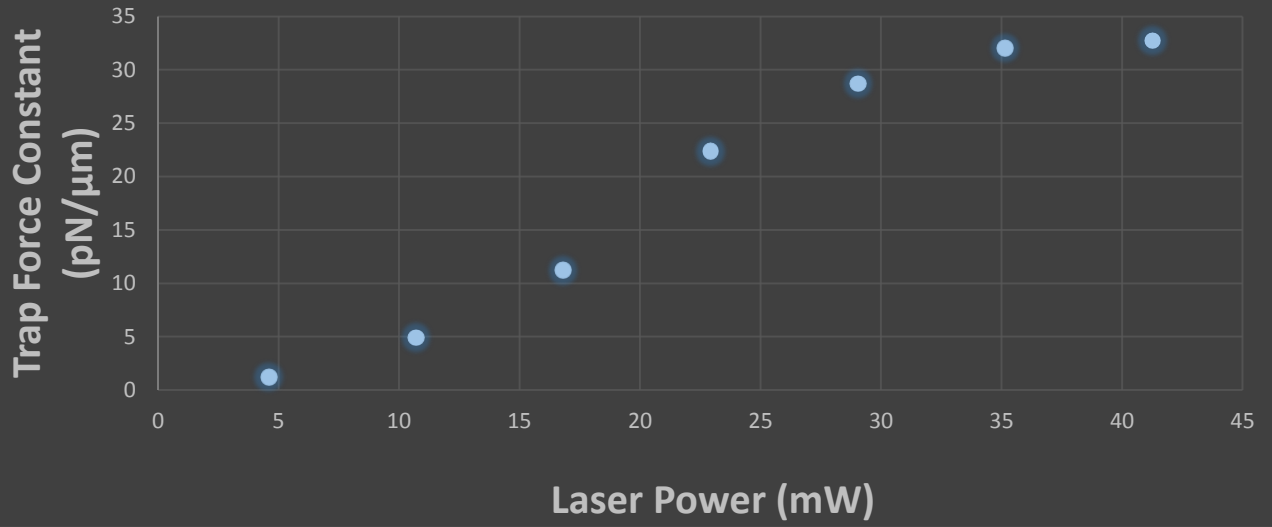
As the laser power is increased, the average variance decreases. This is equivalent to the theoretical spring constant of the system increasing.



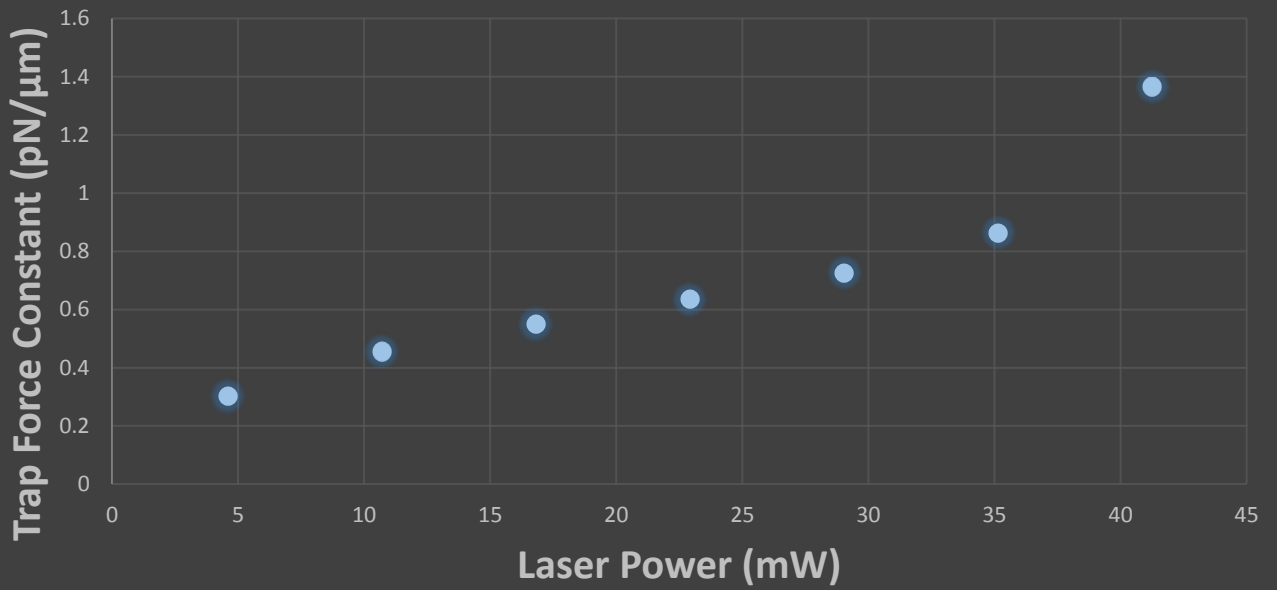
The legend in this graph describes the laser power in milliwatts. As the power is increased, the variance decreases. Our CCD camera was capturing 409 frames per second. You can see that the particle's Brownian motion was decreasing.

From the average variance calculated for each power, a corresponding spring constant (k) can be calculated using the equation at the top of this document. We calculated the spring constants for a range of powers using the variance in the x and y directions:

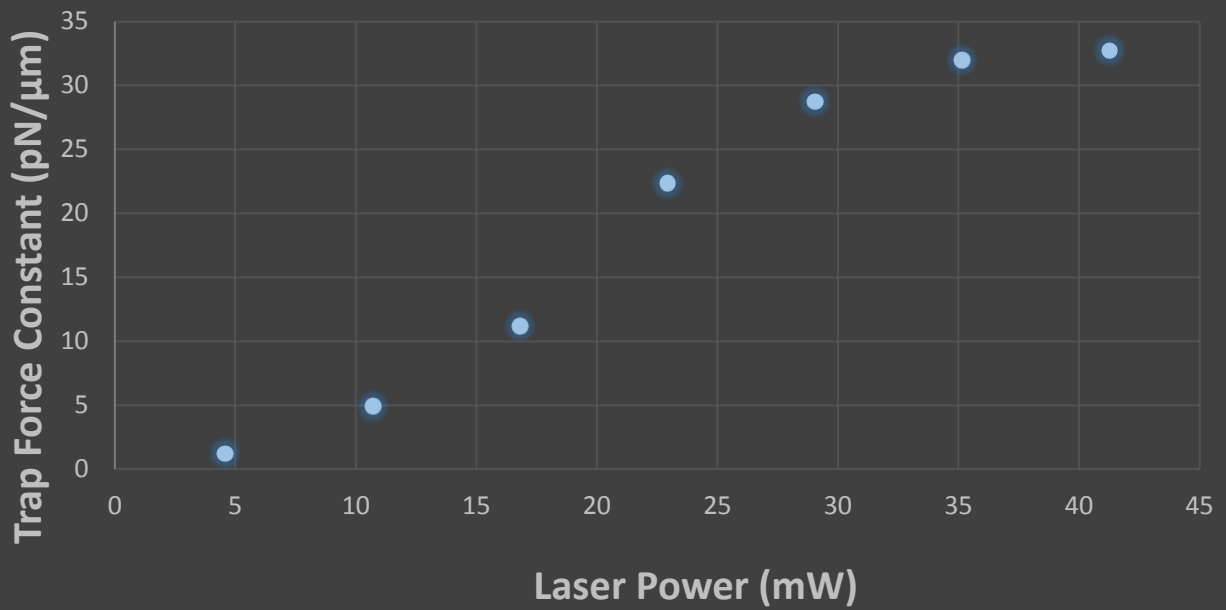
X-Axis Force Constant (637nm)



Y-Axis Force Constant (637nm)



X-Axis Force Constant (980 nm)



Y-Axis Force Constant (980 nm)

