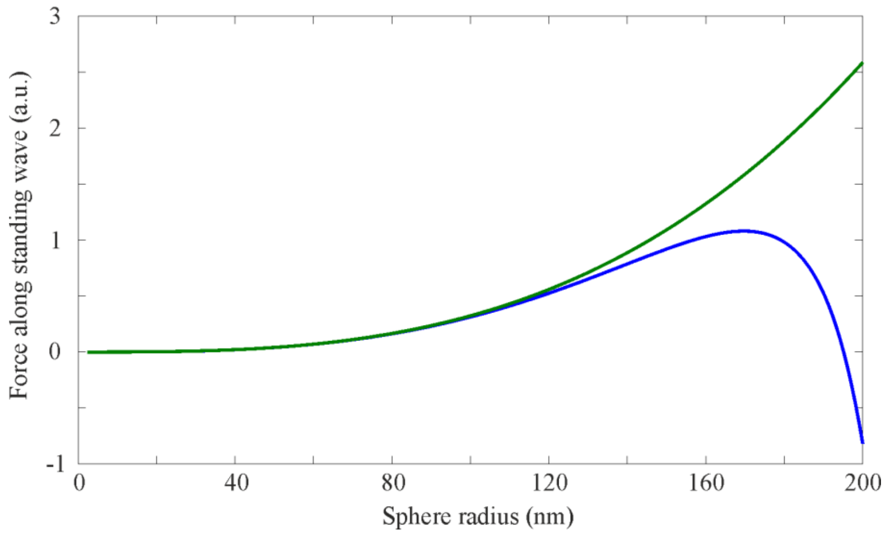
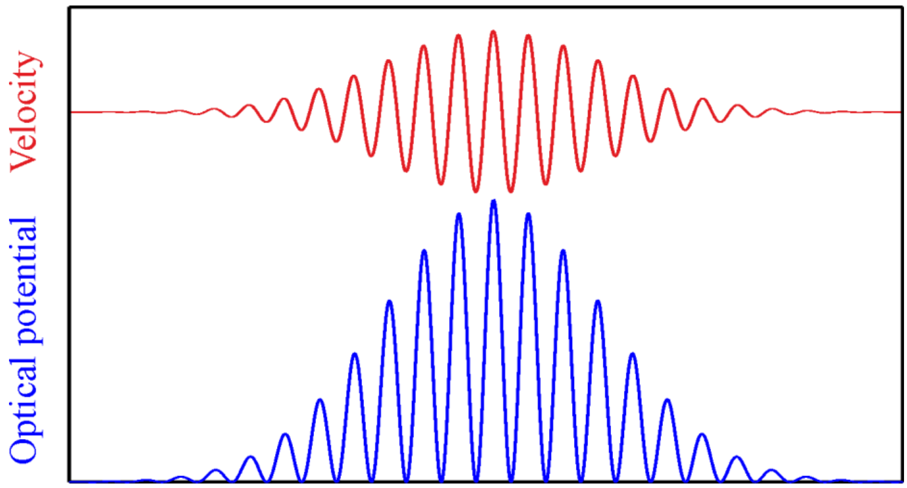
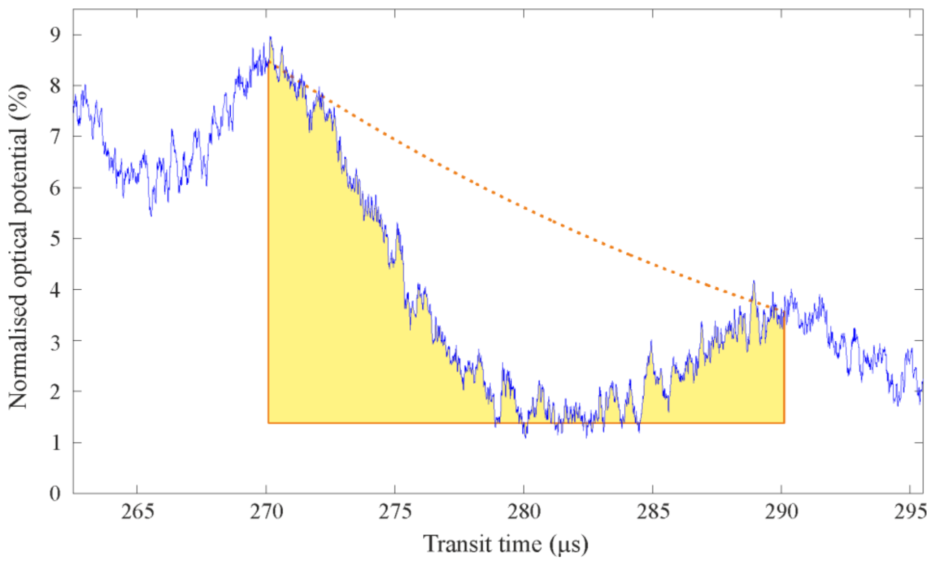


Supplementary Figure S1| Size dependence of the optical force on a dielectric sphere. Green curve: sphere treated as a point-like particle ($F_z \propto U_0$). Blue curve: full Mie-description ($F_z \propto U_z$) taking into account the finite size of the particle. All parameters as introduced in the main text and Fig. 1.

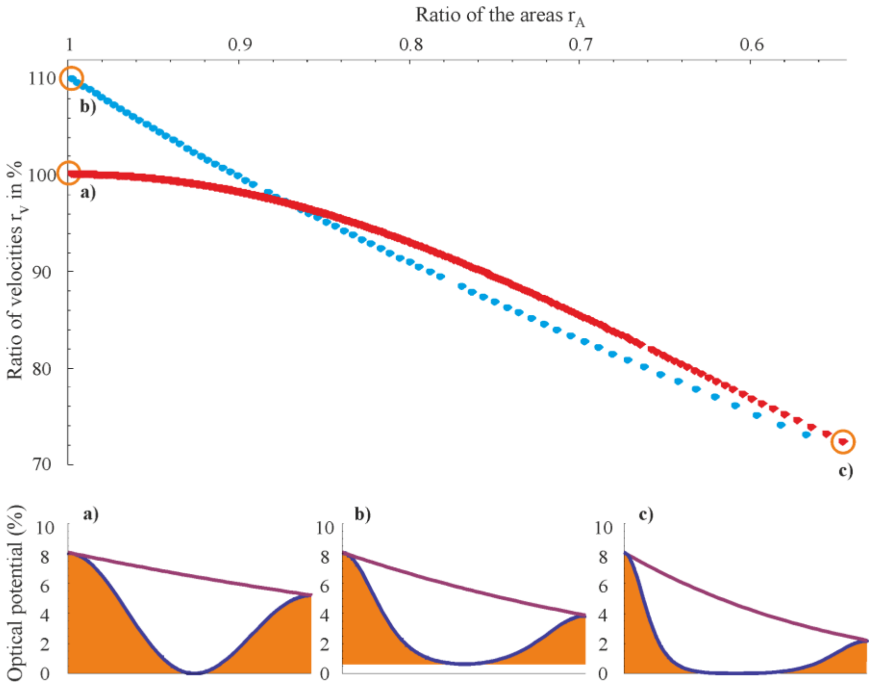


Supplementary Figure S2| Calculated optical potential and velocity for a test particle. The particle runs over a weak standing light wave with a static (unmodulated by the particle) field amplitude.



Supplementary Figure S3| Assessing the uncertainty of the velocity measurement: experiment.

The final velocity can be determined by measuring the peak separation of the optical potential curve ($\propto I_S$) in the exit wing of the Gaussian cavity beam. One may argue that the true exit velocity, i.e. the velocity of the free particle, may differ from the value in the last wells where the particle is still weakly trapped. The truthfulness of the measured and final free velocity can, however, be assessed as follows: We determine the area ratio $r_A = 2A_1/A2$, which compares the area A_1 underneath I_S here shaded in yellow with the total area under the Gaussian envelope enclosed by the orange box - both in the same time window. As shown in Supplementary Fig. S4 this ratio is a quantitative indicator for whether we underestimate or overestimate the free exit velocity by measuring the value in the last weak trapping potential. The experimental data shown here are those of the particle presented in Fig. 3 of the main text.



Supplementary Figure S4| Relation between area ratio r_A and the truthfulness of an exit velocity measurement.

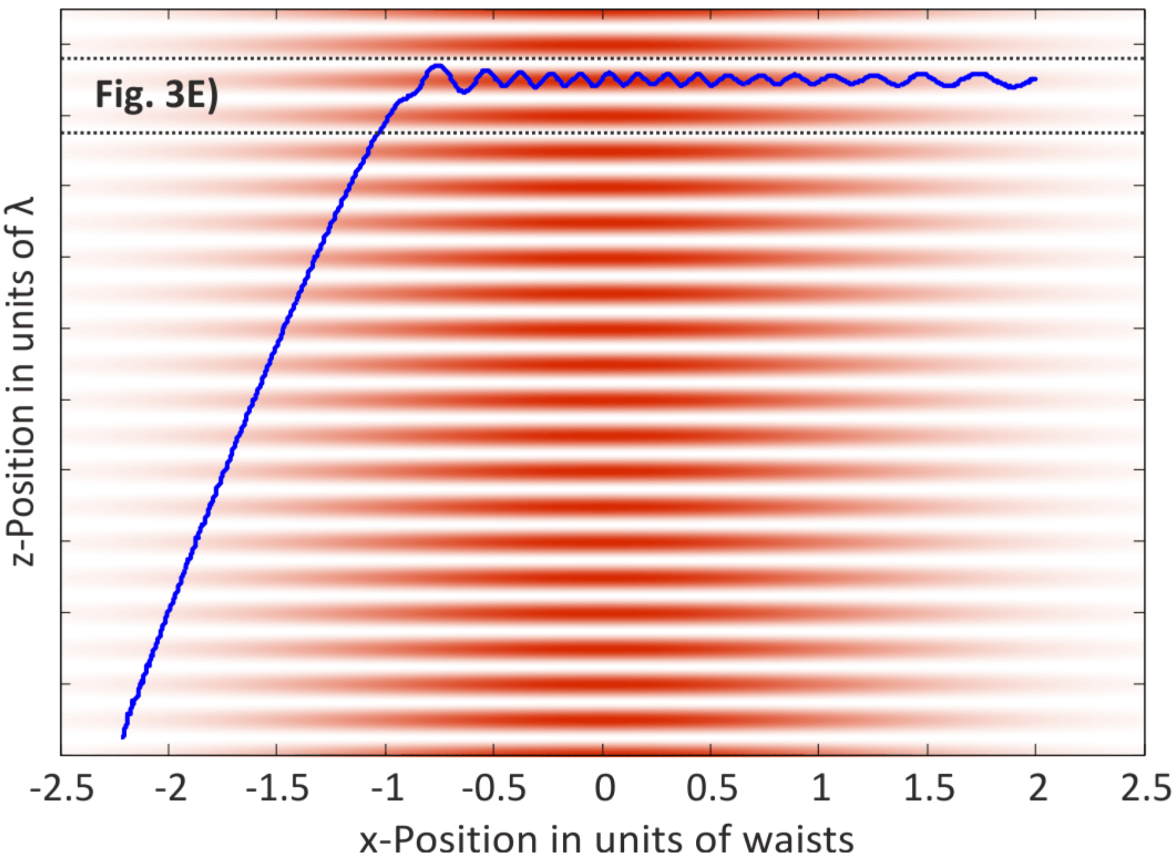
Bottom panel: Area ratios for three prototypical cases, corresponding to a particle that is (a) untrapped (b) trapped and (c) nearly trapped.

We simulate the final exit of a particle under these conditions and the corresponding scattering curve. This allows us to extract the velocity ratio $r_v = r_m/r_f$, i.e. the ratio between the measured and the true final velocity as a function of the area ratio r_A for trapped (blue) and un-trapped (red) trajectories (top panel).

a) The particle is hardly influenced by the optical potential while it moves over the standing wave. Therefore, both r_v and r_A are close to 1.

b) The particle is trapped in the standing wave and $r_A \approx 1$. However, the measured velocity is about 10% higher than the actual final velocity of the particle after leaving the cavity mode.

c) A particle at the border between being trapped and untrapped. The measured velocity appears to be slower than it actually is after leaving the cavity ($\sim$ 28 %). However, it also shows a deviation of r_A from 1 by more than 45 %.



Supplementary Figure S5|Reconstructed particle trajectory. In complement to Fig. 3, the particle trajectory is displayed from the entrance to the exit of the Gaussian mode. When the particle enters it runs over many periods of the standing wave field along *z*. About one waist away from the beam center the particle is laterally trapped and channeled and cooled before it finally leaves the beam. Fig. 3E in the main text shows only the data marked by the dashed box for better clarity.