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Pulling Particles Backward Using a Forward Propagating Beam
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— Can the scattering force of a forward propagating beam pull a particle backward? A photon carries a momentum of $\hbar k$, so one may expect light will push against any object standing in its path. However, light can indeed "attract" in some cases. For example, if light is focused to a spot, small particles will be attracted towards it due to the gradient force. But it is probably more appropriate to say that the gradient force "grabs" rather than "pulls", as the particle will remain stable in the trap after being drawn to the focus. Here, we discuss another possibility—a backward scattering force which is always opposite to the propagation direction of the beam so that the beam keeps on pulling an object towards the source without an equilibrium point. In the absence of intensity gradient, using a light beam to pull a particle backwards is counter intuitive. The underlining physics is the maximization of forward scattering via interference of the radiation multipoles. We show explicitly that the necessary condition to realize a pulling force is the simultaneous excitation of multipoles in the particle and if the projection of the total photon momentum along the propagation direction is small, attractive optical force is possible.

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