

## **CLASSICAL ANALOGUES OF ATOM MANIPULATION TECHNIQUES USING LASER RADIATION**

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An effective macroscopic de Broglie wavelength  $\lambda_{\text{eff}}$  can be defined for a classical particle interacting with an oscillating field, so its dynamics resembles that of a quantum particle in a static (dipole) potential [1, 2]. In the "quasi-classical" case, when the potential spatial scale is large compared to  $\lambda_{\text{eff}}$ , the particle average motion is adiabatic, meaning that there occurs no photon exchange with the oscillating field. Otherwise, a charged particle exhibits quantum-like effects such as obeying discrete eigenstates near the potential local minima [2], tunneling through "classically forbidden" regions [3], and stochastically reflecting from both positive and negative potentials [2, 4], which can be used for particle beam slicing on time scales down to attoseconds [5]. Resonant fields can as well trap particles exhibiting natural oscillations (e.g., Larmor rotation in a magnetic field) [1, 4] or transmit them asymmetrically, hence acting as one-way walls [6-9]. Classical particles might also be channeled along predefined diffusion paths in momentum space, allowing for Sisyphus-like cooling and other applications [4].

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- [1] I. Y. Dodin and N. J. Fisch, Phys. Plasmas **14**, 055901 (2007).
- [2] I. Y. Dodin and N. J. Fisch, Phys. Rev. Lett. **95**, 115001 (2005).
- [3] I. Y. Dodin and N. J. Fisch, Phys. Rev. E **74**, 056404 (2006).
- [4] I. Y. Dodin and N. J. Fisch, Phys. Lett. A **349**, 356 (2006).
- [5] I. Y. Dodin and N. J. Fisch, Phys. Rev. Lett. **98**, 234801 (2007).
- [6] N. J. Fisch, J. M. Rax, and I. Y. Dodin, Phys. Rev. Lett. **91**, 205004 (2003);  
Erratum: Phys. Rev. Lett. **93**, 059902(E) (2004).
- [7] I. Y. Dodin, N. J. Fisch, and J. M. Rax, Phys. Plasmas **11**, 5046 (2004).
- [8] I. Y. Dodin and N. J. Fisch, Phys. Rev. E **72**, 046602 (2005).
- [9] M. G. Raizen, A. M. Dudarev, Q. Niu, and N. J. Fisch, Phys. Rev. Lett. **94**, 053003 (2005).