**Abstract**

**Self-similarity and phase space correlations in anomalous dynamics of ultra-cold atoms**

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We experimentally study the anomalous real-space and phase-space dynamics of ultra-cold atoms in a one dimension. We show that the spatial distribution exhibits fractional self-similarity and is well fitted by a Lévy distribution, in agreement with theoretical predictions [1]. We further show that the position-velocity correlation function $C_{xv}(t)$ builds up on a timescale related to the initial conditions of the ensemble and then decays asymptotically as a power-law, following a simple scaling theory involving the power-law asymptotic dynamics of position and velocity [2].

[1] Y. Sagi, M. Brook, I. Almog, and N. Davidson, *Observation of Anomalous Diffusion and Fractional Self-Similarity in One Dimension*, Phys. Rev. Lett. **108**, 093002 (2012)
[2] G. Afek, J. Coslovsky, A. Courvoisier, O. Livneh, and N. Davidson, *Observing Power-Law Dynamics of Position-Velocity Correlation in Anomalous Diffusion*, Phys. Rev. Lett. **119**, 060602 (2017)