Lévy flights random walk for photons in atomic vapors

I. C. Nunes[1], J. P. López[1], T. Passerat de Silans[*,1]
[1] *Departamento de Física, Universidade Federal da Paraíba, Caixa Postal 5008, 58051-900, João Pessoa – PB, Brazil*

*email: thierry@otica.ufpb.br

Light propagation in turbid media can be described as a random walk of the photons. Depending on the scattering mechanism, a long jump between successive scattering events may exist, characterizing the random walk as superdiffusion Lévy flights. Photons propagation in resonant atomic vapor is one of such system that exhibits Lévy flights [1], with the random walk generated by successive spontaneous emission events followed by absorption by the vapor itself, phenomenon known as radiation trapping. During the radiation trapping emitted frequency is redistributed by Doppler effect with eventually a photon emitted in emission profile wings and performing a long jump before self-absorption. Lévy flights are usually characterized by jump-length distribution decaying asymptotically as a heavy-tailed power law $P(l) \propto l^{-1-\alpha}$, with Lévy parameter $\alpha<2$, which can be measured from diffusive transmission dependence on opacity or on starting point of the random walk. For the case of atomic vapor the parameter α is not uniquely defined but varies with jump-length such that the power law slope can be locally defined. As it, atomic vapor is a rich platform for studying Lévy flight, for instance, we show that it can be used for investigating influence of jump-length truncation, due to finite size of the vapor, on the random walk [2]. Emission profile may be Doppler in the absence of collisions between atoms or exhibit long Lorentz wings when collisions are present. We are currently investigating the possibility of observing collisional effects even in the limit of dilute vapor (collisional rate lower than spontaneous emission rate). This should be possible since a single long jump of a photon emitted in the Lorentz wings, although rare, should govern the diffusive transmission. Preliminary results will be presented.

References

1. N. Mercadier, W. Guerin, M. Chevrollier, R. Kaiser, *Nat. Phys.* **5**, 602-605 (2009).
2. A. S. M. Macedo, J. P. Lopez, T. Passerat de Silans, *Phys. Rev. E* **104,** 054143 (2021).