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Continuous superradiance sustained by a stream of excited atoms

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Superradiance of cold atoms in an optical cavity can be harvested to act as an optical frequency reference. By using an electronic transition much narrower spectrally than the cavity mode (i.e., by operating in the bad cavity limit), the frequency of the outcoming light is little affected by mirror position fluctuations –a signifiant limitation to short term stability in standard optical clocks.

For these new frequency references, called superradiant lasers [1], the present challenge is to demonstrate a continuous emission regime. Here, we will discuss one of the proposed architectures to sustain indefinitely superradiant emission: using a continuous stream of excited atoms to inject energy into the optical cavity mode. We will briefly introduce the experimental project in our laboratory, and then focus on a theoretical description of this object. Our efforts [2] provide intuition into the synchronization mechanism of new atoms onto the collective atomic dipole in cavity; into the role and importance of inter-atomic correlations; and into the coherence time of the collective atomic dipole, setting the linewidth.

[1] J. G. Bohnet, Z. Chen, J. M. Weiner, D. Meiser, M. J. Holland, J. K. Thompson: A steady-state superradiant laser with less than one intracavity photon, Nature 484, 78 (2012)

[2] B. Laburthe-Tolra, Z. Amodjee, B. Pasquiou, M. Robert-de-Saint-Vincent: Correlations and linewidth of the atomic beam continuous superradiant laser, SciPost Phys. Core 6, 015 (2023)

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