Spontaneous emission and quantum memory within a 1D atomic lattice

M2 internship / PhD position

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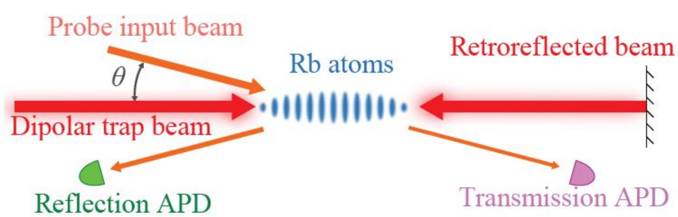
In the cold-atom group at INPHYNI, we are studying **collective effects** in the interaction of light with laser-cooled atoms. Among those phenomena, **superradiance** and **subradiance** correspond to the accelerated and slowed down decay of light scattered by ensembles of atoms, compared with the single-atom decay rate. In the recent years, we have studied super- and subradiance in disordered cold-atom samples, where the position of each atom is random.

Now, we want to study what happens when the atoms are trapped in a one-dimensional lattice made of a retro-reflected optical tweezer. In that configuration, the atomic density becomes modulated in space with a periodicity close to $\lambda/2$ (where λ is the wavelength of the transition), which creates a modulation of the refractive index induced by the atoms. This modulation opens a **photonic band gap**, i.e., a range of frequency where light cannot propagate, but only at a given angle determined by the Bragg condition. Light incoming from the outside at the Bragg angle is reflected. One can tune the Bragg condition by adjusting the periodicity of the lattice via the laser wavelength. We have recently studied the fast transient dynamics of the Bragg reflection.



The experiments that we now want to realize are:

1) Measurement of the scattering rate modification within the band gap. Is it superradiant or subradiant?
2) Measurement of the "slow light" effect that should occur on the photonic band edges.
3) Adding electromagnetically-induced transparency (EIT) and sending pulses, we will store the optical excitation (as in a quantum memory protocol) and exploit the Bragg reflection to read it out in different directions.
4) Finally, we will explore the use of this system for novel quantum gates and topological photonics.

Depending of the candidate level (M2 or PhD), a part or all this program will be addressed. We are seeking a motivated student with experimental skills in optics and some basic knowledge in atomic physics, optics, light-matter interaction. The subject is **mainly experimental**, although numerical simulations may be performed for comparison with the experiment. He/She will work with a second-year PhD student already on the experiment. Collaboration with French (Paris, Toulouse, Bordeaux) and international (Brazil) partners is expected.

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