Scattering rate within a 1D atomic lattice

M1 internship

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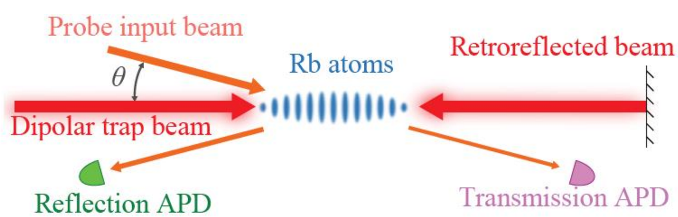
In the cold-atom group at INPHYNI, we are studying **collective effects** in the interaction of light with laser-cooled atoms. Among those phenomena, **superradiance** and **subradiance** correspond to the accelerated and slowed down decay of light scattered by ensembles of atoms, compared with the single-atom 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 experiment that we now want to realize are is the measurement of the scattering rate modification within the band gap. Is it superradiant or subradiant?

In this context, for this internship, we propose to investigate this question numerically by using the coupled-dipole model, which is a standard tool to deal with this kind of system. Matlab codes are already available in the team, and previous publication show that the Bragg reflection can be simulated this way. The goal of the internship is to study the emission diagram (Is there an increase or a decrease of the emission in the Bragg direction?) and the temporal dynamics (Is there an increase or a decrease of the decay rate in the Bragg direction?).

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