**Research project proposal for a PhD program**

Rydberg atoms [1], owing to their intrinsic large dipole moments, are promising tools to detect electromagnetic fields [2] in the range 1 GHz – 1 THz using electromagnetically induced transparency (EIT). First detections, around 10 years ago, triggered a great interest and many developments throughout the world. Within a consortium of 4 French research laboratories and one company (PEPR contract “CARAMELS”, together with ONERA, LumIn, IEMN and Thales), we will study this technique in various points of view.

So far, the technique has been applied to alkali atoms in a hot vapor cell. In Laboratoire Aimé Cotton, we propose to study the use of cold ytterbium atoms in order to push the sensitivity limit whether working on hot atoms or cold atoms. Indeed the electronic structure presents specificities, with narrow transitions and long lived states, that could allow to narrow down the device signal by orders of magnitude, improving the ultimate field sensitivity accordingly.

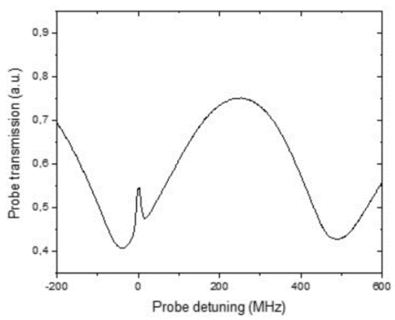

Figure 1 : EIT spectrum within Yb Doppler absorbtion profile, with 6s33d $^1D_2$ Rydberg state

For instance the two wavelengths to couple the $6s^2\ ^1S_0$ ground state to the first singlet 6s6p $^1P_1$ excited state at 399nm and then to Rydberg states at around 396nm will allow to compensate Doppler effect to better than 99%. We have performed a preliminary test of EIT with 6s33d $^1D_2$ Rydberg state on a hot beam of ytterbium atoms (figure 1) and developed a model describing the EIT width as a function of experimental parameters. The PhD will start with completing this study in order to derive optimal sensitivity and test its results experimentally on our ytterbium beam.

Another interesting approach is to use a probe light on the narrow intercombination transition at around 556nm from the ground state towards the 6s6p $^3P_1$ excited state that possesses a linewidth of 180 kHz. This has been proposed in [3] to obtain an increased sensitivity on EIT or EIA (electromagnetically induced absorption). In order to benefit fully from divalent atoms properties, the use of cold atoms will be necessary as it will avoid any Doppler broadening or Fourier transform limited broadening. All the above studies will be reproduced on cold atoms to test ultimate sensitivities.

[1] T. F. Gallagher, Rydberg atoms (Cambridge University Press 1994)

[2] Fancher, *et al. IEEE Transactions on Quantum Engineering* **2**, 1-13 (2021).

[3] Zhou, *et al. Phys. Rev. A* **105**, 053714 (2022).

Contact : patrick.cheinet@cnrs.fr