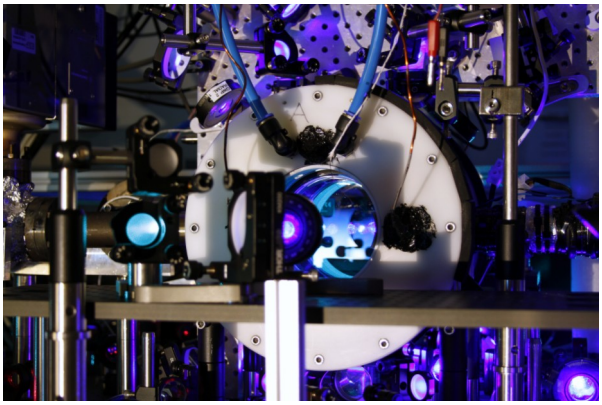
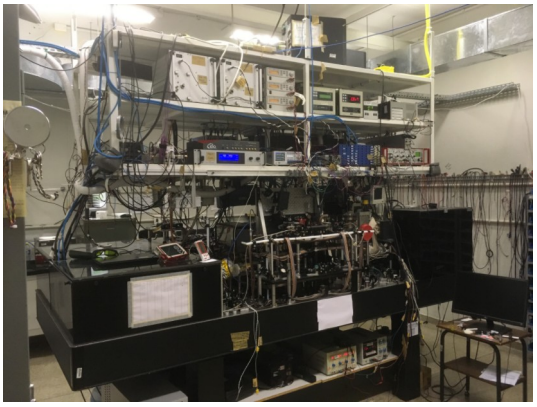
Announcement: PhD open position
Closing application date: May 15th, 2024

ICorQuant
Intensity correlations to probe light diffusion within a dense atomic cloud





We are looking for a talented and motivated student to fulfill a position as PhD candidate at IFSC – USP – Brazil, under the supervison of Prof. Dr. Philippe W. Courteille and co-supervision of Prof. Dr. Raul Celistrino Teixeira in the field of light scattering by cold atomic clouds, in close collaboration with the group of Dr. Mathilde Hugbart at INPHYNI-CNRS, Nice, France. The scientific project is detailed at the end of this announcement.

Key Highlights:

- Duration: 3 years (mostly in Brazil; 3 stays of 1-2 months each at INPHYNI, France)
- Start date: August 2024
- Funding: The approved PhD scholarship includes full funding for three years of study, plus full funding for the three stays (one per year) at the research group of Dr. Mathilde Hugbart in France, spanning a total duration of 5 months (1-2 months per stay).

Desired Qualifications:

- Strong background in optics and lasers.
- Prior experience in atomic physics experiments involving hot or cold atoms is desirable, but not mandatory.
- Good level of English (written and spoken), to join an international team.
- Motivated and passionate about scientific inquiry.
- Excellent communication and collaboration skills.

To Apply:
Interested candidates are invited to send their applications via email to teixeira@df.ufscar.br, including a brief CV and a motivation letter.

Important! The accepted candidate will need to provide a grade from the Brazilian Exame Unificado de Física (EUF - https://euf.ifi.unicamp.br/EUF/listarevento.aspx?12024EUF) or an equivalent exam by August 2024, to be inscribed at the Graduate School (pós graduação) of IFSC-USP. This condition can be checked at https://www2.ifsc.usp.br/pos/wp-content/uploads/2023/04/Edital-Fluxo-Continuo_2023_2024.pdf.

Scientific project

For atomic samples reaching densities satisfying $\rho > \lambda^{-3}$, with λ the wavevector of resonantly scattered light, the interaction of atoms with light is intrinsically collective; the near-field terms of the electric field scattered by the next-neighbours of one atom couple strongly to it, bringing new effects to the light propagation at the atomic samples such as the coherent transfer of excitations among close atoms, the blockade of excitations in the cloud[1], the increase of the mean-free-path and the diffusion constant of light within the sample. Such modifications are related to very fundamental problems in physics, as for instance they were shown to prevent the emergence of the 3D Anderson localization of light[2] and to establish fundamental limits on the index of refraction of cold matter[3]. This highly-correlated state will be probed via specific observables:

Diffusing Wave Spectroscopy (DWS) to probe modifications in the path length distribution – DWS[4] is a very useful technique that probes, through the measurement of the intensity correlations of scattered light, the velocity distribution of the cloud in the single scattering regime, and gives access to the distribution of scattering events in the multiple scattering limit[5]. For dense clouds, the simple picture of a random walk of photons that collide with individual atoms is challenged by the strong, coherent interaction between next-neighbours. Preliminary numerical simulations show a larger width and a long tail of the temporal correlations for light scattered by samples of high densities, suggesting robustness against Doppler dephasing for light. We intend to directly measure such modifications in our experiment.

Validity of the Siegert relation for dense samples – The Siegert relation establishes a connection between the field ($g^1(\tau)$) and intensity ($g^2(\tau)$) temporal correlations of the light scattered by a sample of disordered scatterers. We are currently numerically investigating the impact of the correlations induced by the near-field scattering terms to the Siegert relation; violations of it can configure a probe of useful light correlations or entanglement within the atomic cloud. The PhD candidate will experimentally search for violations of the Siegert relation for light scattered by dense atomic clouds, and interpret them with the help of numerical simulations.

The collaboration with the group at INPHYNI-CNRS, which has a strong experience in the measurement of statistical correlations of the light, in particular with the DWS technique applied to cold atoms, and in the study of collective effects in the light-matter interaction, will be of utmost importance for the success of the PhD project. The PhD candidate will also participate in the investigation of related problems at the French laboratory, such as the quest for antibunching on the light scattered by an extended, dilute cloud of cold atoms.

1 A. C. Santos *et al.*, PRA **105**, 053715 (2022).
2 A. Eloy *et al.*, PRA **97**, 013810 (2018).
3 COFECUB-CAPES (2023-2026), STIC-AMSUD (2021-2022), ANR PRCI (2020-2024), COFECUB-CAPES(2017-2020), CNRS-FAPESP (2016-2018), CNPq Special Visiting Professor for Robin Kaiser (2014-2017), COFECUB-USP (2011-2014) and FP7-People-IRSES Coscali (2011-2015)
4 A. S. Prasad *et al.*, Nat. Photonics **14**, 719 (2020).
5 J. Hinney *et al.*, PRL **127**, 12 (2021).