C2 *Proposal of a possible IUPAP Workshop*

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From Cold Atoms to Astrophysics (and back)

Quantum mechanics, atomic physics and astrophysics have a long common history. The observation of discrete absorption lines of atomic vapors has been crucial for the development of the Bohr model with fundamental contributions to the development of the quantum mechanics. When the astrophysical community went beyond the mere detection of light intensities and used spectral information of detected light, a new window opened to the understanding of the constitution, formation and evolution of stars, planets and other astrophysical objects. Even quantum optics has entered the field of astrophysics, with the intensity correlation experiments on performed by Hanbury-Brown and Twiss in the 50s, even though optical interferometry, as pioneered by A. Labeyrie and now implemented on the VLTI, has been taken over to increase the angular resolution of astrophysical objects. The idea to have a workshop that can cover the following topics:

i) Interference corrections
ii) Levy flights
iii) Polarimetry
iv) Random lasing
v) Optical Forces

Beyond the scattering properties of light in astrophysics, the mechanical feedback of light onto the atomic motion needs to be considered. In astrophysics, it has been known for a long time that equilibrium properties of self-gravitating systems are rather special: negative specific heat, canonical (fixed temperature) and microcanonical (fixed energy) ensembles are not equivalent. These anomalous features of long range interacting systems have been fully appreciated by other physicists' communities only later. When long range forces are considered, local properties of the particles in the cloud depend on all particles and thus on the total size of the system. Understanding the self-organizing behavior or the thermodynamics and out-of-equilibrium dynamics of long-range interacting systems is still a challenging objective. This is for instance the situation of gravity in 3 dimensions and leads to the so-called Jeans instability, responsible for the formation of large scale structures such as galaxies. In recent years it has been shown that statistical physics of long-range interacting systems generally exhibit a whole set of new qualitative properties and behaviors: temperature jumps, long-time relaxation (quasi-stationary states), violations of ergodicity, etc. These long range interactions are also well known in plasma physics, where the Vlasov equations and derivations of this are used to study collective dynamical effects. One can therefore use one components plasmas or trapped ions to study such collective effects with long range interactions.

Possible Experts (outside the cold atom community)

(i) Intensity corrélation : D. Dravins

(ii) polarimetry of light scattered by hot atomicvapours : J. Stenflo

(iii) randomlasers : H. Cao, D. Stone

(iv) Scattering : Robin Kaiser