凝縮系物理学ゼミナール
Condensed Matter Seminar

Location: Room 413, School of Science Bldg. 5 (理学 5 号館 413 号室)
Time and date: 13:30 – 15:00, Wednesday, 16 April 2014

Exciton many-body effects and quantum condensation

Speaker: Prof. Monique Combescot
(Institut des NanoSciences de Paris, Université Pierre et Marie Curie, CNRS)

Abstract:

In a first part, I will introduce the new many-body formalism I have constructed to handle composite quantum particles with fermion exchanges included in an exact way. I will mostly stay qualitative, showing pictures, called *Shiva diagrams*, which visualize what can happen to composite particles made of undistinguishable fermions. This quite general formalism does not use Green functions but commutators involving the creation operators of these composite particles.

I will then turn to semiconductor excitons made of two fermions, one electron and one "hole". These bosonic particles should undergo a Bose-Einstein condensation (BEC). Their composite boson nature however makes this condensation quite unusual. Indeed, due to spin and orbital degrees of freedom, electron-hole pairs can have five different "spins": (-2, -1, 0, 1, 2). As the "dark" states, (-2, 2), not coupled to light, have the lowest energy, the exciton condensate must be dark - which explains why this condensation has not been seen for decades through luminescence experiments. Fortunately, as bright excitons (-1, 1) are coupled to dark excitons (-2, 2) through fermion exchanges, a bright component appears in the exciton condensate above a density threshold: coherence in the bright part of this *gray* condensate can then be observed. Under a further density increase, excitons dissociate into an electron-hole plasma, this dissociation possibly occurring along a phase separation between exciton gas and electron-hole liquid. Finally, the intrinsic attraction between electrons and holes can lead to BCS-like Cooper pairs made of electron and hole.

In a third part, I will show very recent experimental data from François Dubin's group which support the existence of a *gray exciton condensate*.

References:

M. Combescot, O. Betbeder-Matibet and F. Dubin, "The many-body physics of composite bosons", Phys. Rep. **463**, 215 (2008).

M. Combescot, O. Betbeder-Matibet and R. Combescot, "Bose-Einstein condensation in semiconductors : the key role of dark excitons", Phys. Rev. Lett. **99**, 176403 (2007).

R. Combescot and M. Combescot, ""Gray" BEC condensate of excitons and internal Josephson effect", Phys. Rev. Lett. **109**, 026401 (2012).

M. Alloing, M. Bein, D. Fuster, Y. Gonzales, L. Gonzales, R. Combescot, M. Combescot and F. Dubin, "Evidence for Bose-Einstein condensate of excitons", arXiv:1304.4101.