BEC of photons in a dye-filled microcavity: inhomogeneities, coherence and interactions

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Bose-Einstein condensation (BEC) is a universal phenomenon which occurs when a system of identical bosons at thermal equilibrium occupy the ground state in enormous numbers. By optically pumping a 1.5-micron long, dye-filled resonator, we can achieve both thermal equilibrium of photons and a well-defined ground state. Thus, the first room temperature BEC was demonstrated [1]. We have become only the second laboratory to create this quantum-fluid state of light.

There are many recent published theoretical models of photon BEC, some using rate equations, other fully quantised matter-light interactions. Some of our steady-state observations, such as the variation of critical pump power with pump spot size, contradict the predictions of these simple models, giving a challenge to our theory collaborators [2]. We will also present some of the results of a detailed comparison between our data and the model of Kirton and Keeling [3].

We have measurements of the first-order coherence, which show that the condensate has a longer coherence time than the thermal cloud. Our interferometer is capable of measuring the transverse coherence length, to give a full picture of $g^{(1)}(t - t', \mathbf{r}, \mathbf{r}')$. Dye-microcavity photons are thought to have the weakest particle-particle interactions of any system exhibiting BEC, although the mechanism and magnitude is currently undetermined. We have shown that even these interactions should be detectable in the momentum-resolved spectrum [4], and have begun experiments.

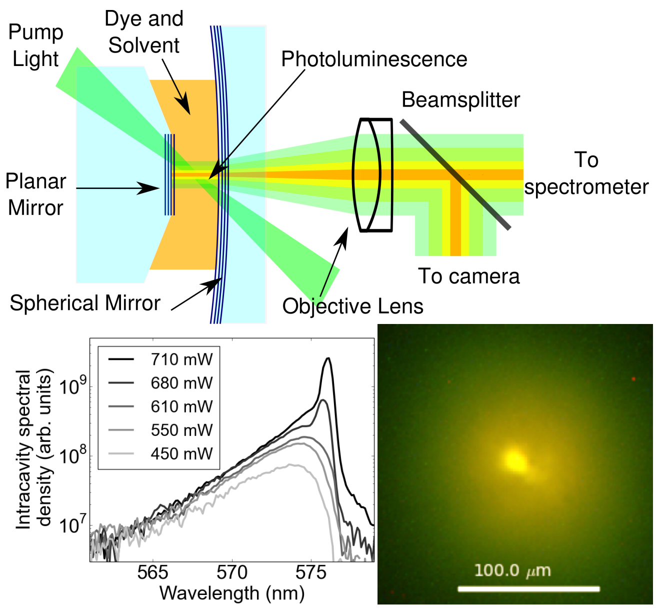

Figure 1: *Top: experimental setup for demonstrating Bose-Einstein condensation of photons. Lower left: the intracavity spectrum, which is compatible with a Bose-Einstein distribution at room temperature, showing macroscopic occupation of the ground state. Lower right: a real-colour image.*

References

[1] J. Klaers et al, Nature, **468**, 545 (2010)
[2] J. Marelic and R.A. Nyman, Phys. Rev. A. **91**, 033813 (2015)
[3] P. Kirton and J. Keeling, Phys. Rev. Lett, **111**, 100404 (2013)
[4] R.A. Nyman and M.H. Szymanska, Phys. Rev. A, **89**, 033844 (2014)