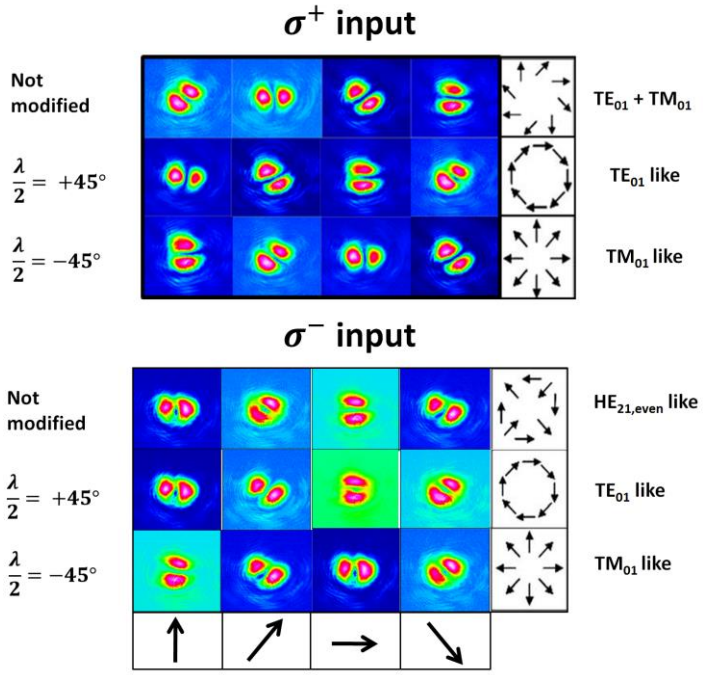
Interaction between cold atoms and selectively excited higher order modes of an ultrathin optical fiber

Okinawa Institute of Science and Technology [1], ◦Thomas Nieddu[1], Jinjin Du[1], Síle Nic Chormaic[1]

E-mail: thomas.nieddu@oist.jp

Interfacing of ultrathin optical fibers and cold atoms has recently gained interest for the study of quantum systems [1]**.** These fibers feature a strong evanescent field at their waist, thereby providing an intense and tightly focused beam over long distances. The evanescent field may interact with atoms in the vicinity of the fiber [2], facilitating the creation of trapping potentials for atoms along its waist [3]. Spontaneously emitted light from excited atoms may preferentially couple into the nanofiber-guided modes [4]. In addition, such fibers are ideal for exploring nonlinear optical effects that usually require very high laser powers [5]. Most of the studies in this area to date have focused on the fundamental fiber-guided mode. Here, we exploit the higher order modes (HOM) of the ultrathin optical fiber as they can lead to fiber-traps with tunable geometries and increased control over the position of the trapping sites. In particular, combinations of HE_{21} could be used to transfer orbital angular momentum (OAM) to ensembles of atoms surrounding the fiber. As a first step, we have achieved selective excitation of each true-mode of the LP_{11} group in a few-mode fiber, following an experimental procedure similar to that of Volpe and Petrov [6]. These modes (Fig.1) were then reinjected into an ultrathin optical fiber installed in an ultrahigh vacuum chamber, and their interaction with an ensemble of cold atoms was studied experimentally.



References

[1] T. Nieddu *et al.*, J. Opt. **18**, 053001 (2016).

[2] F. Le Kien *et al.*, Phys. Rev. A **74**, 033412 (2006).

[3] F. Le Kien *et al*, Phys. Rev. A **70**, 063403 (2004).

[4] A. V. Masalov and V. G. Minogin, Las. Phys. Lett. **10**, 075203 (2013).

[5] R. Kumar *et al.*, New J. Phys. **17**, 123012 (2015).

[6] G. Volpe and D. Petrov, Opt. Commun. **237**, 89 (2004).