Thermo-Reccurent Nematic Random Lasers

V. Barna[a], S. Ferjani[b], A. De Luca[b], C. Versace[b] and G. Strangi[b]

[a]*Faculty of Physics, University of Bucharest, PO Box Mg-11, 077125, Bucharest, Magurele, Romania*
[b]*LICRYL CNR-INFM and Center of Excellence CEMIF.CAL Department of Physics, University of Calabria, I-87036 Rende (CS), Italy*

Experimental investigations of random laser action in a partially ordered, dye doped nematic liquid crystals with long-range dielectric tensor fluctuations are reported. Above a given pump energy value, a randomly distributed series of bright tiny spots appear, giving rise to a strongly fluctuating spatio-temporal emission pattern. The spectral analysis reveals discrete sharp peaks of about 0.5 nm (FWHM). The unexpected surviving of interference effects in recurrent multiple scattering of the emitted photons provide the required optical feedback for lasing in nematics. Coherent backscattering of light waves in orientationally ordered nematic liquid crystals manifests a weak localization of light which strongly supports diffusive laser action in presence of gain medium. Unlike distributed feedback mirror-less lasers, this system can be considered as a cavity-less microlaser where the disorder unexpectedly plays the most important role, behaving as randomly distributed feedback laser. In particular, was studied the role of the thermally modulated order parameter in the diffusive laser action observed in systems having various sizes and different confining geometrical constraints. Important experimental evidence reveal a strong temperature dependence of the random lasing characteristics in the nematic phase and in close proximity of the nematic-isotropic (N-I) phase transition. A lowering of the laser emission intensity as the temperature increases is strictly related to the shift of the lasing threshold as function of the temperature, even though the pump energy is kept fixed. The optical losses increase, owing to the thermal fluctuation enhanced scattering, and drive the input-output smoother behavior until the system stops to lase, because situated below threshold. The unexpected reoccurrence of random lasing at higher temperatures, in proximity of N-I transition is found to be related to a different scattering mechanism, the micro-droplets nucleation and critical opalescence. These scientific aspects overlook features of great interest characteristic of laser physics and material science.

References

(1) Strangi G., Ferjani S., Barna V., De Luca A., Scaramuzza N., Versace, C., Umeton C., Bartolino R., *Optics Express*, **2006,** *14*, 17, 7737-7744.
(2) Ferjani S., Barna V., De Luca A., Scaramuzza N., Versace C., Umeton C., Bartolino R., Strangi G., *Applied Physics Letters*, **2006,** *89*, 121109.
(3) Ferjani S., Sorriso L-V. Barna V., De Luca A., De Marco R., Strangi G., *Physical Review E*, **2008,** *78*, 011707.
(4) Ferjani S., De Luca A., Barna V., Versace C., Strangi G., *Optics Express*, **2009**, in press.