Whispering Gallery Mode Resonators: from rainbow lasers to mechanical oscillators

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Whispering gallery mode resonators (WGMR) have attracted a great interest in the last decade. WGMR have been fabricated in different geometries, solid and hollow, spherical, toroidal, and bottled shaped. Hollow spherical WGMR or microbubble resonators (MBR) are the last arrived in the family of resonators. The approach used for their fabrication is based on surface tension driven plastic deformation on a pressurized capillary [1], similar to glassblowing. Using such technique we are able to fabricate large surface area and thin spherical shells with high quality factor (Q).

MBR are efficient phoxonic cavities that can sustain both optical photons and acoustic phonons [2]. It has been demonstrated that solid spheres and MBR can be used to study Turing comb patterns (Kerr modulation) and Stimulated Brillouin Scattering (SBS) [3,4]. The acoustic phonons responsible of SBS are related to the material, and they are in the GHz range for bulk silica. Radiation pressure is another mechanism that also leads to excitation of acoustic phonons with lower frequencies, in the range of hundreds of kHz to tens of MHz in the case of silica MBR. The frequency of such oscillations occurs very close to the mechanical eigenfrequencies of the cavity.

Similar to toroidal and solid spherical WGMR [5], MBR show a similar route to chaos: periodic doubling bifurcation and a set of discrete lines into a continuum, and finally a continuum.[6,7] For very large MBR, the transition to chaos is direct, avoiding the sequences of periodic doubling bifurcations. We have also studied the temporal behavior of the cavity, the coexistence and the suppression of the oscillation while generating Turing comb patterns. The oscillation suppression occurs when the light is coupled to the resonance with red detuning (the pump has a lower frequency than the resonance). In this case, we generate photons in other resonant modes equally spaced (four wave mixing processes).

The observed phenomenology can be explained by the geometrical characteristics of a MBR. MBRs are spheroidal WGM resonators with quite dense spectral characteristics. The geometrical dispersion is normal and large with values of several hundreds of kHz. However, the material dispersion is quite large at the wavelengths considered in this work. The total dispersion is anomalous and large, also with values of several hundreds of kHz, as expected for very large MBR. Thus, Kerr comb formation is allowed for all MBR used in this work.

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