INTERNSHIP PROPOSAL

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Microlasers & geodesics

Quantum chaos is a research field dedicated to semiclassical physics [1], i.e. the relationship between a quantum system and its classical counterpart. The predictions are investigated in any wave system, namely quantum, acoustic, microwaves, optics,… One of the major hypothesis is the localization of eigenmodes on classical periodic trajectories, which was evidenced with quasi two-dimensionnal microlasers some times ago [2]. Recently it became possible to fabricate three-dimensionnal (3D) microlasers with high optical quality by direct laser writing [3], in particular surface-like microlasers. We investigated Möbius strip microlasers and demonstrated by experiments and FDTD simulations that the modes were located on periodic geodesics [4], a geodesic being the shortest path between two points on a surface. A typical wavefunction and its corresponding periodic geodesic are presented in Figure (a).

Geodesics cannot be analytically calculated on a Möbius strip, and required a numerical algorithm. The internship is hence dedicated to sphere-like microlasers where it is easier to identify periodic geodesics. Two different designs are shown in Figures (b-c). The microlasers are fabricated by Dominique Decanini (C2N, CNRS), the FDTD simulations are performed by Xavier Chécoury (C2N, UPSay), the experiments are carried out by Mélanie Lebental (C2N, ENS-PS), and theory related to differential geometry is supervised by Guillaume Bossard (CPhT, Ecole Polytechnique). The student will be involved in some of these tasks according to his/her likings.

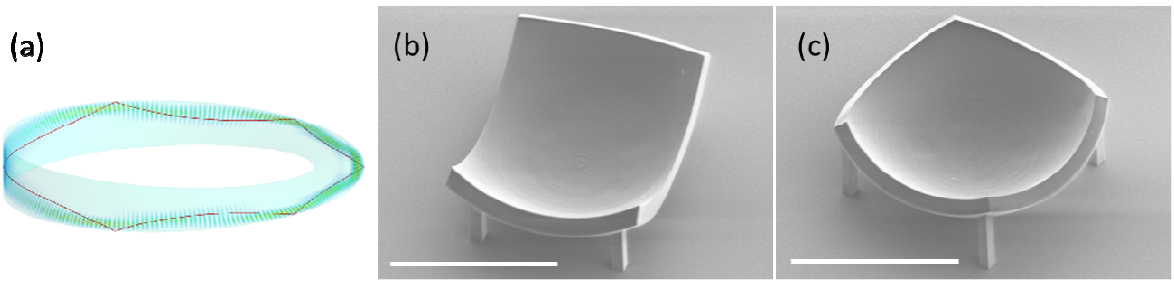

Figure: (a) Wave function in a Möbius strip. The red line is a periodic geodesic. (b-c) Scanning Electronic Microscope (SEM) images of microlasers fabricated by direct laser writing. The scale bar corresponds to 50 µm. Figures (b) and (c) illustrate two different designs for a square on a sphere.

[1] H.-J. Stöckmann, *Quantum chaos, an introduction*, Cambridge University Press (1999).
[2] A. Pascal et al., *Waves and rays in plano-concave laser cavities, Part II: a semiclassical approach*, European Journal of Physics, vol. 38, 034011 (2017).
[3] M. Guidry et al., *Three-dimensional micro-billiard lasers: The square pyramid*, Europhysics Letters, vol. 126, 64004 (2019).
[4] Y. Song et al. *Möbius strip microlasers: a testbed for non-Euclidian photonics.* Phys. Rev. Lett., vol. 127, 203901 (2021). Editor's suggestion.