Cells as lasers

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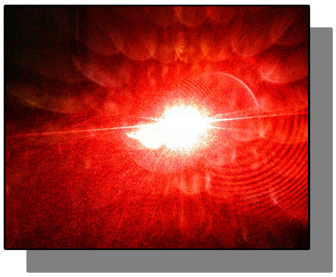
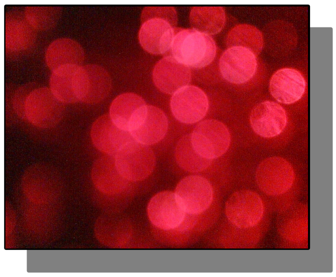
Live biological cells as laser sensors – can it be true? Cast your mind back to the time you first heard of cybernetics, with nanorobots inside the blood which augment and analyse diseases. In 2014, the interdisciplinary researchers are on the verge of crucial steps towards attaining this goal.

▪ **Scenario** – Imagine a living cell, consisting of an inhomogeneous medium surrounded by a thin membrane. We are investigating the conditions under which such a cell could support a particular kind of optical resonance to lase. The cell medium must also function as an *optical gain medium* (Gather & Yun[1]). The next step is to establish that a cell-analogue can sustain these resonances, called *whispering gallery modes.* Then our research will provide an evidence-based evaluation of their use, and their tolerance of imperfections in the cell shape and structure, for biosensing applications.



(Above/below) | Dramatic illustrations, of our first new 'windows into the body'.



▪ **Optical micro-resonators** represent an important tool for biosensing[2], because the resonance peaks of the whispering gallery modes are highly **sensitive** to the external environment. These modes are 'bound' electromagnetic waves that travel the surface of a material/medium interface, producing an *evanescent field*, affected by nearby biomolecules such as virions, bacteria and DNA[3-8]. These modes are easily **trackable**, as the modes are quantised, i.e. occurring only at specific wavelengths, with narrow peaks (high quality-factors). As a result, the resonator acts as a **sensor** of its environment.

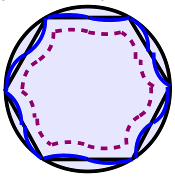


Figure 1 | Whispering gallery modes in a circular cross-section of a resonator.
Azimuthal modes: number of nodes on the surface.
Radial modes: radial penetration of mode into medium.

Spherical resonators: we have developed tools to tell us if a cell is a good candidate for a micro-resonator laser.
If it can support whispering gallery modes,
It is readily applicable for biosensing.

▪ **Methods: 1**. *Finite-Difference Time-Domain (FDTD)* is a computational tool that we have recently customised[9] for the specific purpose of simulating the mode spectra of deformed micro-sphere and micro-shell resonators. **2.** Experimental analogues of cells under our investigation include polyelectrolyte multilayer near-spherical shells, manufactured by coating porous templates with organic solvents, resulting in a liquid interior[10].

▪ **Advantages and Significance**

The FDTD method can be tailored for more realistic scenarios. FDTD can investigate the effect of different mode-excitation methods on the energy output (as measured by the flux), and its angular distribution[9].
Tuning the characteristics of resonators for optimal power coupling reduces trial-and-error fabrication costs and aids the development of biosensing tools, and the investigation of new sensor configurations that otherwise would not have been found.

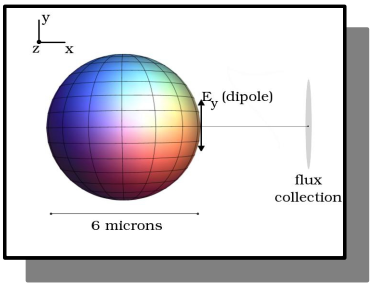


Figure 2 | Flux-collection from a microsphere in FDTD.

References

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