MAN (**M**odal **A**nalysis of **N**anoresonator)

MAN is an open-source software for analyzing electromagnetic micro and nanoresonators. It is composed of two solvers, **QNMEig** and **QNMPole**, which compute and normalize the quasinormal modes (QNMs), i.e. the quality factor Q and mode volume V. **QNMEig** operates under the COMSOL Multiphysics platform; **QNMPole** can be used with any frequency-domain electromagnetic solver. These solvers are valued by an increasing number of toolboxes, which allow a transparent analysis of nanoresonators with analytical formulae: reconstruction of the field in the modal basis, scattering and extinction cross-section spectra, LDOS spatial and spectral maps, Purcell factor, multipolar decomposition, generation of second-harmonics, temporal domain analysis … In the present version, the toolboxes are solver dependent; this is formal and with a minor effort, the user using one solver may benefit from the toolboxes developed for the other solver. In future versions, the toolboxes will be shared.

QNMEig, launched in 2018, can be thought as an extention of the existing COMSOL modal solver that additionally normalizes the QNMs and handles resonators made with dispersive media, e.g. metals. The QNMs are computed by solving a quadratic polynomial eigenproblem derived from Maxwell's equations. Thus, a large number of modes (set by the user) are computed with a “single” computation without preconditioning. This makes the solver more effective than **QNMPole**, that compute QNMs one by one. We recommend the use of **QNMeig** in general. **QNMEig** is accompanied by several toolboxes for reconstructing the field in the QNM basis, computing the multipolar decomposition of QNMs. It additionnally includes many COMSOL models (plasmonic nanoantennas, photonic crystal cavities, nanoparticles, gratings, 2D photonic crystals, in free space or on substrates).

QNMPole, launched in 2013, is an open-source Matlab code for computing and normalizing the QNMs of plasmonic or photonic micro/nanoresonators. It is very simple to use. It is very general too (it could be used with any frequency-domain Maxwell solver and for any geometry). The use of **QNMPole** is recommended if one just needs to compute a few modes, or if the permittivity of some constitutive materials does not follow a *N*-pole Lorentz-Drude model (required for **QNMEig**). It is accompanied by a pedagogical Matlab toolbox that can be used to calculate modal absorption/extinction cross-sections and Purcell factor map. For COMSOL Multiphysics, we additionally provide the Matlab programs that operate under Matlab-COMSOL livelink.