Steady-state Ab initio Laser Theory (SALT) is a method for directly finding the steady-state solutions of the semiclassical laser equations without integrating them in time. It is formulated to deal with laser cavities/systems of arbitrary complexity, such as modern micro-cavity, nano, photonic crystal and random lasers. The theory treats the openness of the cavity exactly and the non-linear modal interactions to infinite order, (within the stationary inversion approximation), and it has been shown to be very accurate for N-level lasers, even for multimode lasing high above threshold. The SALT equations are non-linear, coupled wave equations, and have previously been solved using a special non-hermitian basis set that is well-adapted to the lasing problem, known as the constant-flux (CF) basis. Very recently several groups have developed a direct solution method which is significantly more computationally efficient, bringing three-dimensional vector SALT solutions within reach, and hence making it possible to use SALT for realistic laser design and control. Also quite recently, it has been shown how to calculate the laser linewidth quantitatively from SALT, leading to a formula that automatically includes all of the known corrections to the Schawlow-Townes formula (incomplete inversion, Petermann factor, alpha factor and bad-cavity correction). Finally, a number of novel phenomena have been discovered by application or extension of the SALT approach, such as re-entrant lasing, PT-symmetric laser-absorbers, and time-reversed lasers. This talk will review (briefly) the SALT theory and new laser phenomena just mentioned.

Fig. 1: Calculated emission pattern from a 2D random laser using SALT, adapted from Tureci et al., Science 320, 643-646 (2008).