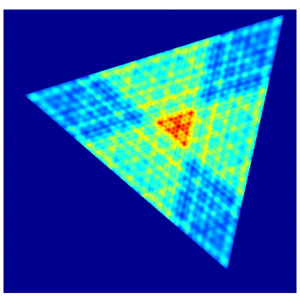
0.0.1 Using Fox-Li method to calculate resonator modes

This exercise illustrates modal calculations and specifically the Fox-Li approach as applied to the topic of "fractal resonator modes." There are several related papers included in this exercise package that describe the notion in a few different contexts. While the modes may not be truly fractal, they do exhibit a rich transverse structure. To capture this structure the simulation needs to be executed with a sufficient resolution. The fractal geometry of the modes explored in this project is not at focus of this exercise — they simply serve to define a physical context in which application of the BPM method becomes non-trivial.

We are using the basic method to calculate the "most stable unstable mode" in a given geometry. To do this is rather straightforward; one simply needs to BPM-propagate initially arbitrary beam amplitude as it does in reality (or it *would* if there was no chromatic dispersion) from mirror to mirror, apply spatial mask(s) representing apertures, and occasionally renormalize the solution to keep it from disappearing...

The following picture illustrates an intensity profile of a mode that arises in a cavity which has one mirror in the shape of a triangle:



The fundamental mode of an unstable resonator with a triangular mirror. One can see a hint of a fractal geometry in the triangular patterns which repeat (approximately) on different scales.
The calculations in this sections are somewhat sensitive to the utilized resolutions, a difficulty partly caused by a square lattice computational grid. In such situations, it is useful to "misalign" the geometry of the problem with the grid axes. This is done here by rotating the triangular mirror. This makes it "the worst case" scenario i which an insufficient resolution manifests most readily (which is indeed what one wants).

The task:

- Implement a BPM-based Fox-Li method to calculate modes in simple optical resonators. Your implementation should provide capability for simulation of different shapes (e.g. polygons) of resonator mirrors or apertures inserted into cavities.
- Use your program to find the fundamental mode of an unstable resonator with a triangular mirror (or aperture) as described in the attached paper (Karman et al. *Fractal modes in unstable resonators*, Nature 402(1999)138.)
- Demonstrate that the simulation is sound. In particular, show that results are properly resolved, and converged. Show that any parameters that do not characterize the physics of the problem have no or very little influence on the outcome of the simulation.
- Explore simulations for various mirror shapes
- Test the capabilities of your implementation by attempting simulation of large problem (the "size" or difficulty of this simulation is essentially given by how small the wavelength is in comparison to mirror size). Note that one can make an argument for the fractal geometry of the resonator modes only for large Fresnel numbers, and such situations take long to simulate...