



Universidade do Minho



## 21. Curricular Unit

Advanced Physics Topics 1

### Module

Numerical Methods for Finding Stationary Gravitational Solutions

### Type

Lectures and Reading and Study assignment

### Contact hours

18

### Professor/Researcher in charge

Benson Way (U. Cambridge) and Óscar Dias (U Southampton); Contact Professor: Miguel Costa U. Porto

### Summary of Contents

- I. Motivation:** review of black hole theorems (topology, rigidity, no-hair, uniqueness theorems), review of instabilities, review of stationary solutions (solitons and black holes).
- II. Linear perturbation theory and zero modes:** general problem, searching for zero modes (seed of nonlinear problems), solving quadratic eigenvalue problems
- III. The DeTurck method:** stationarity, ellipticity, DeTurck gauge-fixing, Einstein-DeTurck equation
- IV. Boundary Conditions:** asymptotic boundaries, non-extremal Killing horizons, axes of symmetry, boundary conditions and the DeTurck vector, boundary conditions for matter fields
- V. Numerical algorithms and tricks to solve the gravitational equations:** Newton-Raphson algorithm, Ricci flow, finding a seed, turning Points, increasing the dimension of spheres, patching.

### References

O.J.C. Dias, J.E. Santos and B. Way, "Numerical Methods for Finding Stationary Gravitational Solutions," Invited Topical Review, Classical and Quantum Gravity, arXiv:1510.02804 and references therein.

### Evaluation

Written assignment at the end of course.



Universidade do Minho



## Juri

Benson Way (U. Cambridge) and Óscar Dias (U Southampton)