Geometry,
Integrability
and
Quantization

THEORETICAL MODELS FOR ASTROPHYSICAL OBJECTS AND THE NEWMAN-JANIS ALGORITHM

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Abstract. We consider the problem of finding exact solutions of Einstein equations describing gravitational fields generated by isolated sources in order to provide theoretical models for astrophysical objects. To this aim, the Newman-Janis Algorithm is described along with the main results obtained through it and some ambiguities arising in dealing with the Newman-Janis Algorithm are reviewed. Many issues related to the introduction of a cosmological constant term are also pointed out and some detailed examples are discussed.

1. Introduction

General Relativity is a fundamental tool in the description of astrophysical system ranging from the solar system scales to the cosmological ones. Thus one would be able to describe, within this framework, compact isolated astrophysical objects in stationary rotation like neutron stars and white dwarfs. A description of these objects proves to be a very hard task requiring the use of both Quantum Mechanics and Relativity.

To give the idea of how complex is the physics involved in such kind of systems, let us shortly consider the internal structure of a neutron star. It consists of four main shells, whose composition changes dramatically with the radial distance from the center, because of the strong density gradient from the exterior to the interior of the star: *Outer crust*: a lattice of ionized nuclei and a degenerate relativistic gas of electrons (e). *Inner crust*: composed of rich nuclei in β-equilibrium, degenerate relativistic gas of e and a degenerate gas of neutrons (n) in the superfluid phase. *Outer core*: consists of superfluid of n, superconducting protons (p) and a mixture of degenerate e, p and possibly muons. *Inner core*: the last layer whose composition is largely unknown.