Direction des Sciences de la Matière
IRFU
Service d'Astrophysique

# Soutenance de thèse du Service d'Astrophysique

## TRANSITION DEFLAGRATION-DETONATION DANS LES SUPERNOVAE THERMONUCLEAIRES

**Camille CHARIGNON**

SAp

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**Salle Galilée – bât 713**

Over the past 15 years, motivated by the fact that calibrated light curves of type Ia (or thermonuclear) supernovae have become an important tool to determine the expansion history of our Universe, considerable attention has been given to, both, observations and models of these events. The most popular explosion model is the central ignition of a deflagration in the dense C+O interior of a Chandrasekhar mass white dwarf, followed by a transition to a detonation.

After a brief discussion of the progenitor and the most probable way to explosion, I will turn to the physics of white dwarfs and the specific properties of the two types of explosions, namely the subsonic deflagrations and the supersonic detonations. I will show here some new results on deflagrations in the magnetized superconducting plasma of the interior of WDs. Then, I will explain why observational constraints on the nucleosynthesis (Ni and Si) point toward an explosion involving a transition from a deflagration to a detonation (TDD).

In a second part, I will present the most robust and studied progenitor model (the "Single Degenerate" scenario) and the postulated mechanism for the Deflagration to Detonation Transition (DDT), the so called "Zel'dovich induction time gradient mechanism". State of the art 3D simulations of such a delayed detonation, at the price of some adjustments, can indeed reproduce observables. But due to largely unresolved physical scales, such simulations cannot explain the TDD by themselves, and especially, the physical mechanism which triggers this transition, which is not yet understood, even on Earth, for unconfined media. I will then discuss why the current Zel'dovich mechanism might be too constraining for a SNe Ia model, pointing to a new approach.

In the final part, I shall present and discuss our alternative model for DDT in supernovae, the acoustic heating of the pre-supernova (a WD) envelope. An exploratory planar model first proves that small acoustic perturbations (generated by a turbulent flame) are actually amplified in a steep density gradient similar to those of WDs, up to a point where they turn into shocks which can trigger a detonation. Then, this is applied to more realistic models, including, in spherical geometry, the expanding envelope driven by the initial deflagration phase. A parametric study demonstrates the validity of the model for a reasonable range of acoustic wave amplitude and frequency.

To conclude, I shall present some exploratory 2D and 3D MHD simulations, seeking for acoustic source compatible with our mechanism.