

Announce stage Master 2

Carbon in the early Universe: C abundances in CEMP stars from 3D NLTE CH line calculations.

Description :

This internship is proposed in the framework of a collaboration between the LUPM in Montpellier and MPIA and the University of Heidelberg.

In this project funded by DFG and ANR, we aim to address a fundamental question: Was the early Universe carbon-rich? This question arises from the discovery of carbon-enhanced metal-poor (CEMP) stars. CEMP stars without enhancements in heavy neutron-capture elements are thought to be direct descendants of the first generation of stars. However, their extreme levels of carbon enrichment remain puzzling and lack a robust astrophysical explanation.

All previous observational studies of CEMP stars relied on highly simplified 1D LTE models for carbon diagnostics, but this critical assumption has never been verified from first principles. We will address this question through a highly inter-disciplinary program, combining methods of molecular quantum mechanics, machine learning, stellar models and spectroscopy, and models of Pop III star formation.

More specifically this internship targets the building of a model molecule for CH, the only carbon diagnostic in these stars, and the use of this model in NLTE calculations. The student will use newly published electron-CH collisional cross-sections (Laporta et al. 2026, Phys Rev A114, 022810), and updates to the photodissociation rates (Sokolov et al. 2025, MNRAS 543, 1435, and 2026, PCCP 28, 7484) to update the model of Hoppe et al. (2026, MNRAS 546, 1) and Popa et al. (2023, A&A 670, A25). The Multi3D code (Leenaarts and Carlsson 2009, ASP Conf. Ser. 415, p. 87) initially developed for atomic species only will be modified to accommodate the molecular dissociation channels.

Test calculations will be made for the Sun, and for benchmark CEMP stars.

Informations complémentaires :

LUPM, Université de Montpellier

En co-direction. Thèse possible ensuite, avec financement acquis.

Laboratoire

LUPM - Laboratoire Univers & Particules de Montpellier

Université de Montpellier

Montpellier

Calendrier prévisionnel

Duration 4 to 6 months starting 2027-03-01

Encadrant

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