Two STEMBACH projects based on Gaia data: introducing Big Data Astronomy in Spanish High Schools

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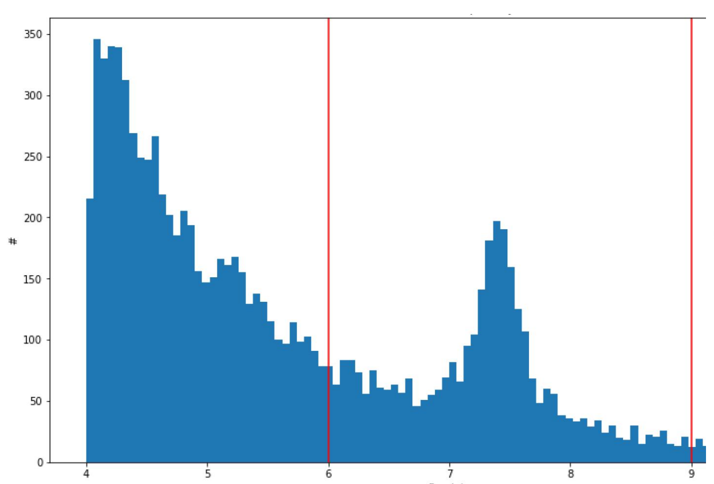
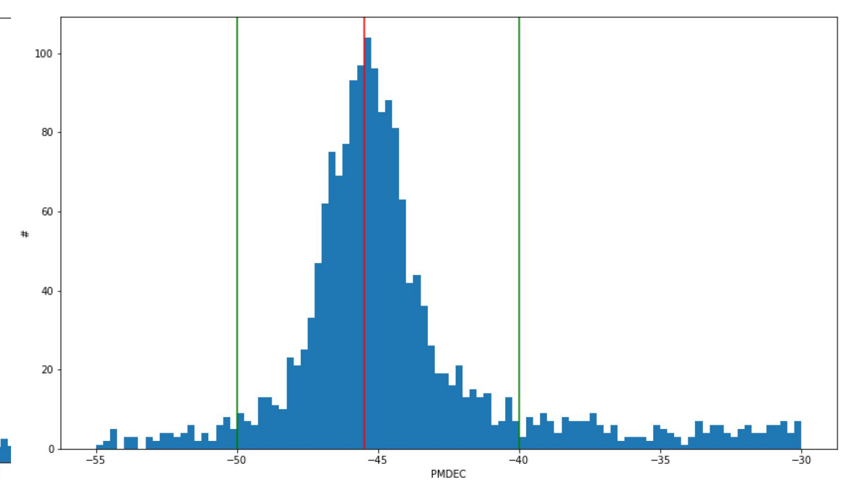
AIM: Gaia ESA mission archives offer excellent opportunities for sparking early science vocations in school, and they are an engaging resource for getting students started on data science. During the 20-21 and 21-22 academic years, our research group has supervised two projects within the STEMbach program (Excellent Bachelor in Science and Technology). Our goal was to encourage high school students' creative thinking and interest in research, technology and innovation through different methods of investigation and analysis.

PROJECT 1: PROPERTIES OF STARS IN STELLAR CLUSTERS: THE PLEIADES AND PRAESEPE

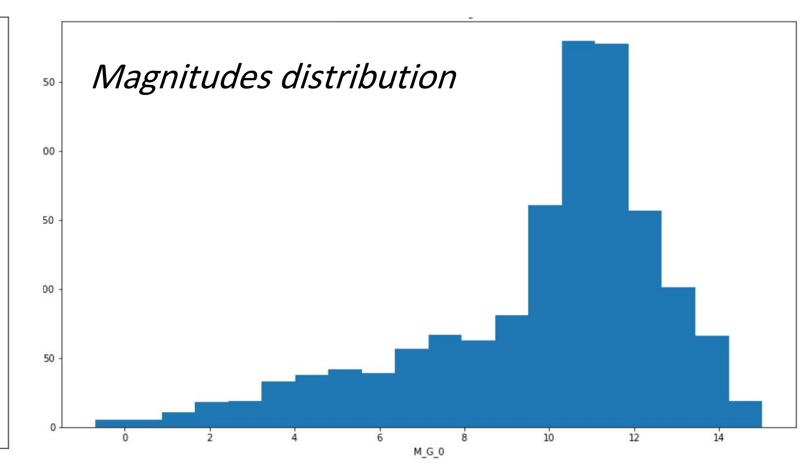
1- MEMBERS SELECTION BY ASTROMETRY. Our first project took place during course 2020-2021, and it made use of Gaia EDR3 precise astrometric and photometric parameters. Our students studied the stellar components of two bright and close by galactic open clusters: Praesepe (M44) and Pleyades (M45). They searched EDR3 archive selecting those objects contained in the neighbourhood of each cluster with similar parallax and proper motion values (in RA and Dec directions) to those reported in the literature for each cluster, taking into account measurement errors.

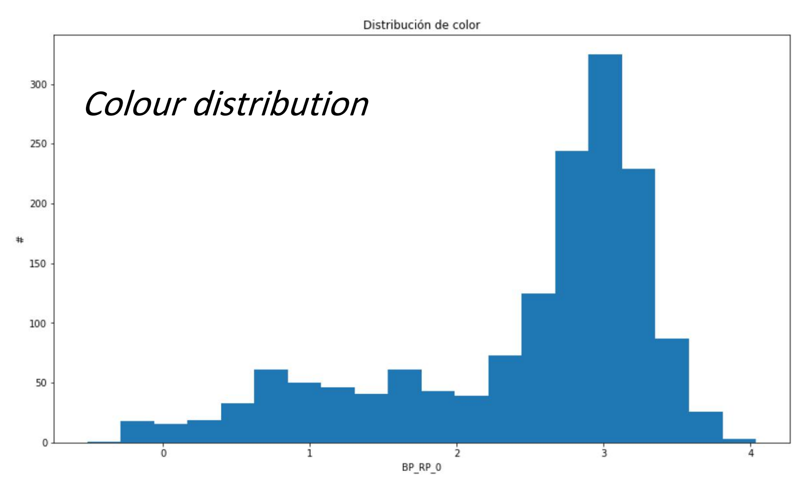


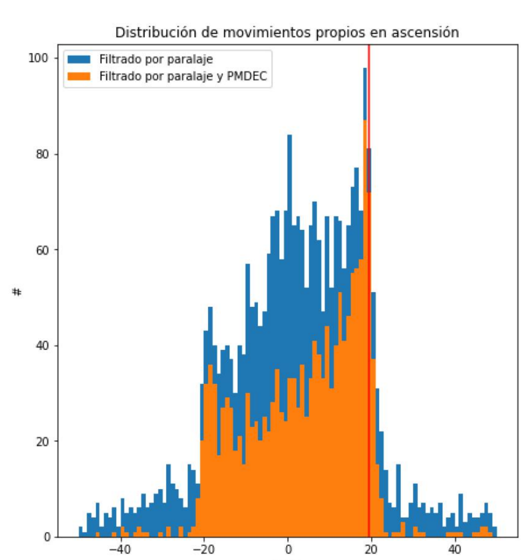
Parallaxes distribution



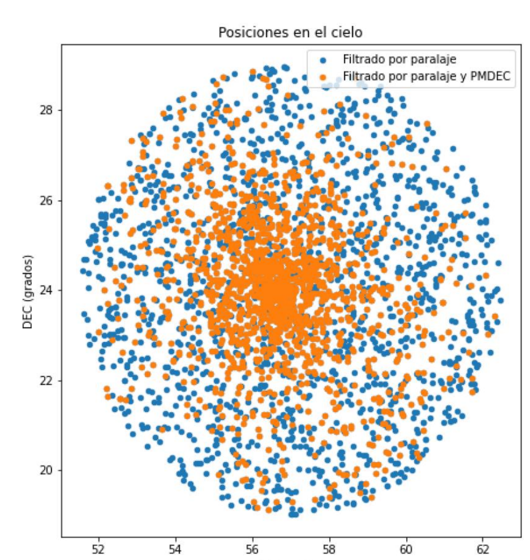
Proper motions in declination



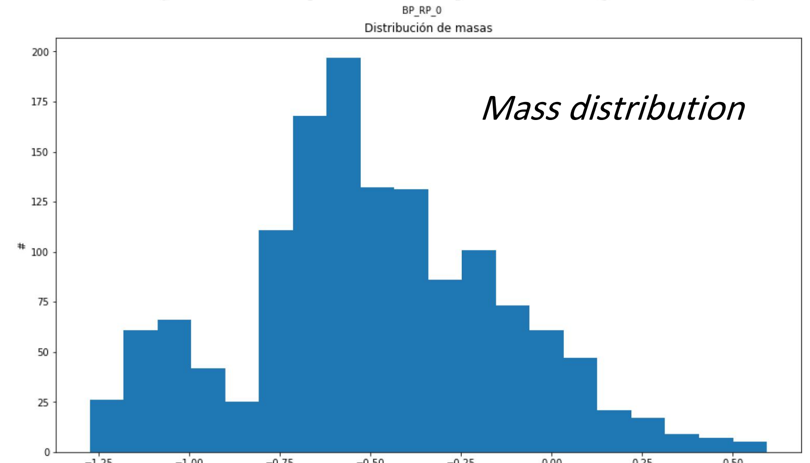


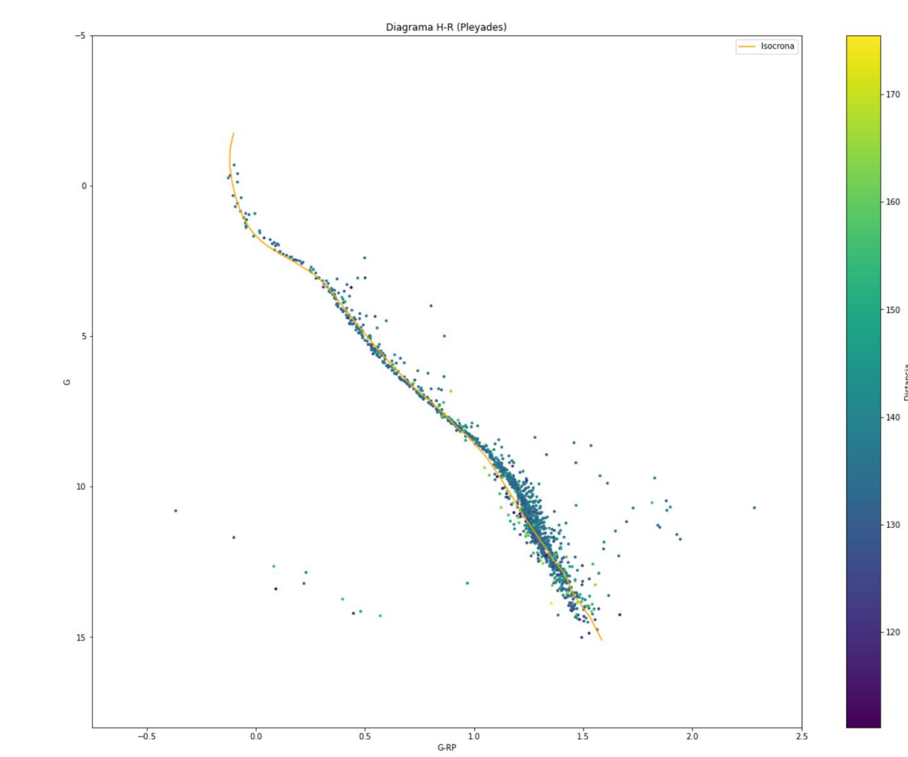


Proper motions distribution in right ascension

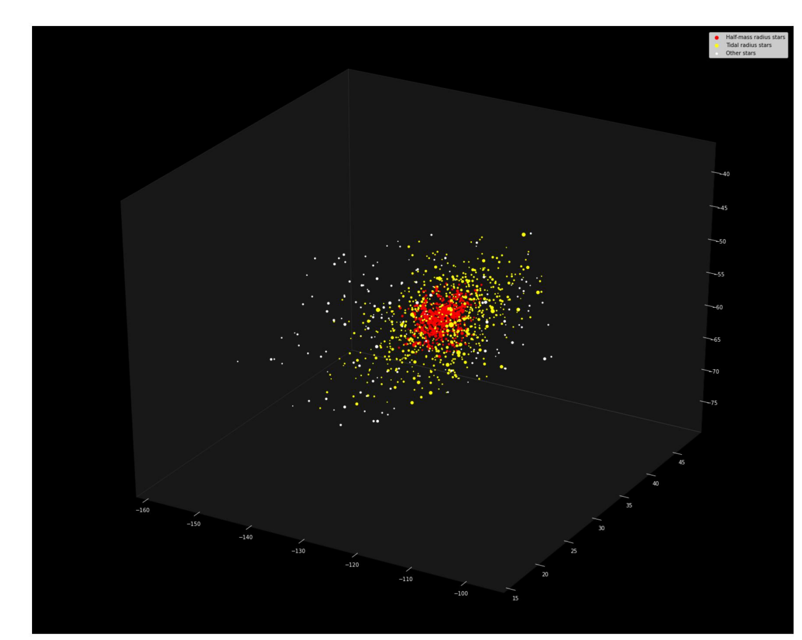


Sky positions





2- COLOR-MAGNITUDE DIAGRAMS. Then, they located the selected stars in a colour-magnitude diagram (G-RP vs M(G)) with the aim of studying their evolutionary state using suited isochrone models. By interpolation, they calculated masses, luminosities, effective temperatures and radii of the sequences of stars. All the steps for the selection of the populations have been carried out using Python programming language and the interactive Jupyter Notebook tool.



Animation temperature

Animation tidal

Animation V3D

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PROJECT 2: DERIVATION OF STELLAR ATMOSPHERIC PARAMETERS USING A SYNTHETIC GRID OF STELLAR SPECTRA AND ARTIFICIAL NEURAL NETWORKS

1- INTRODUCTION. During the 2021-2022 academic year, a Stembach project based on machine learning (ML) was developed. ML techniques are becoming a useful and fast tool to make inferences where there is no known analytic relationship between observables and variables, that are hidden in the physical processes that produce these observables. In this work the students were guided to develop a Multi-layer perceptron neural network model able to estimate the stellar effective temperature, gravity and metallicity from RAVE survey stellar spectra in Gaia RVS instrument spectral region.

2- MAIN OBJECTIVES:

1- Understand the meaning of a stellar spectrum and the information it contains about the physical properties of a star's photosphere, its temperature and gravity, and chemical properties (presence of chemical elements in its atmosphere).

2- Basic knowledge about how the atmosphere of a star is modeled and how theoretical spectra can be obtained that can be used to interpret star observations.

3- Understand how artificial neural network (ANN) algorithms work, what their layered structure is, how they are trained and how their operation is validated.

4- Application of an ANN algorithm trained with star spectra models in the spectral region of the Gaia RVS instrument to obtain the temperatures, gravities and metallicities of a set of star observations. Interpretation of the results in terms of evolutionary state and spectral types.