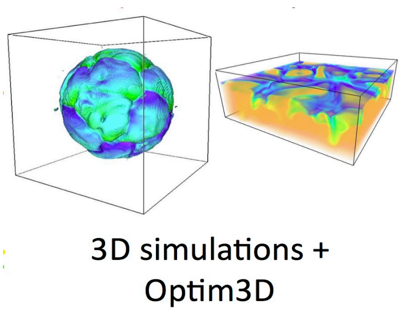
Stellar and Galactic Physics

Formation and Interpretation of Stellar Spectra (FISS)



This training module aims at understanding how the physical conditions in a stellar atmosphere are imprinted in the shape of the light spectrum it emits. The students will focus on the numerical study of the model structure and how to compute synthetic spectra from a given atmospheric model. We'll start with simplified one dimensional models, still in use for modeling spatial averages of stellar spectra. Then we'll turn to more realistic 3D models where the convective motions giving rise to inhomogeneities in density and temperature at the surface of the star are accounted for in details. Several practical applications will be performed using synthetic spectra and spectra obtained from ground and space-based instruments (Very Large Telescope, satellite Gaia/RVS, satellite Hinode ...)

Theory

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Most of the information astronomers obtain from their telescopes is under the form of light spectra, i. e. the radiative energy emitted by the astrophysical objects as a function of the wavelength. More and more relevant physical information may be obtained by increasing the spatial and spectral resolutions. So one of the most fundamental tool for astrophysicists is spectra modeling which allows to interpret the observations. To achieve this, one needs both to describe the physical phenomena taking place in the object and how the photons are created, absorbed or scattered and finally can escape the object and be detected by our instruments. In this Meteor we shall focus on light emitted by stellar atmospheres, which restricts somehow the possible physical mechanisms at play.

In first basic models the atmosphere of the star is supposed to be in hydrostatic and radiative equilibrium (i.e. the energy created at the center of the star is transported through the atmosphere by the radiation without any net loss nor creation inside the atmosphere). We shall study how the atmosphere radiates and show that it emits a continuum spectrum quite close to a black body spectrum, allowing to define the so-called "effective temperature" of the star surface. Increasing the spectral resolution, we can observe absorption lines in the spectrum, i. e. a decrease of the radiative energy on narrow wavelength bands (a few hundredths of nanometers typically). These lines are due to the absorption of photons by chemical elements in the stellar atmosphere. If we increase the spatial resolution we see that the shape of the lines varies along the stellar surface. One of the challenges of the interpretation of stellar spectra is to be able to explain both the wavelength positions and the shapes of the spectral lines (see the Figure). If we can achieve that we get a wealth of information on the physics of the star, such as the abundances of the chemical elements, the acceleration of gravity at the surface, rotation velocity, turbulence, convection, pulsations, etc ...To achieve this goal we need to know how spectral lines are formed. Come and join us if you want to go into the adventure...

Applications

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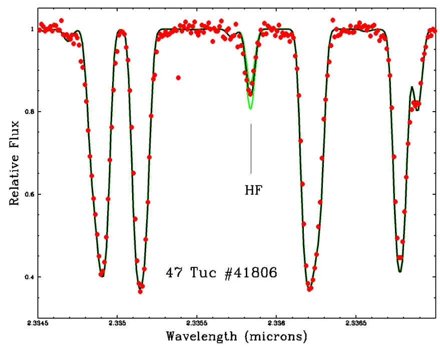
In practical applications the students will be introduced to the numerical computation of atmospheric models and of synthetic spectra from a known atmospheric model (in 1D or/and in 3D). They will also learn standard methods to recover from observed spectra chemical element abundances, radial velocities, and fundamental parameters such as the effective temperature of the star. Spectra obtained from the most efficient spectrometers on Earth and in space will be used.



See also (An interesting book)

Introduction to stellar astrophysics. II. Stellar atmospheres.
E. Bohm-Vitense. Cambridge

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