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DETERMINATION OF AGE AND ORIGINAL CHEMICAL COMPOSITION OF BINARY STARS

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ABSTRACT A numerical method is presented, which is able to determine quantitatively the age t and the initial abundances of helium and metals (Y_0 , Z_0) of a given binary system. Input data are simply the values of mass m , temperature $T_{\rm eff}$ and surface gravity g , of both stars. The procedure works for detached main–sequence binaries, and it does not require any preliminary hypothesis about surface abundances or age. It is assumed that the two stars evolve parallely with no interaction.

THE PROBLEM

A star with a given mass m , because of evolution, changes its physical properties (as effective temperature $T_{\rm eff}$ and surface gravity g), in function of the age t , and of the original abundance of helium Y_0 and metals Z_0. The relation between observational quantities (m ; log $T_{\rm eff}$, log g) and model parameters (Y_0, Z_0 ; t) is provided by evolutionary theory. Is it then possible to compute composition and age (Y_0, Z_0 ; t) of a given star, by knowing (m ; log $T_{\rm eff}$, log g) from observations ?

Here we present an algorithm, which finds out the solution for *individual* main–sequence binaries. In fact, the job is not possible for *single* stars, because of practical limitations (m is unknown), and also because of basic mathematical reasons (equations with infinite solutions). One may wonder why, on the contrary, it is generally possible to solve the problem for a *binary system.* This may be understood as follows.

At time t_0=0 (starting main–sequence *life*), the positions of all stellar masses in the (log $T_{\rm eff}$, log g) plane will define the *Zams* curve; while at time t_1 they will move sideways on another curve (isochrone t_1) , and so on, defining a family of isochrones t_i . For different compositions (Y_0, Z_0), there will be different overlapping families. So, a given star (single mass–point on our plane) may belong to any of the infinite isochrones t_i with different (Y_0, Z_0), intersecting at that point. Only the presence of a companion star (second mass–point) can individuate the *common* isochrone, solving the riddle.

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THE *BOFER* CODE

Our computer code – called *BOFER* – performs linear interpolations among a basic grid of stellar models (Mengel *et al.*, 1979), with different initial compositions (Y_0=.20, .30 ; Z_0=.01, .04) and ages (t_i=0,.07,.1,.2,.5,1,2 Gy), using the corresponding isochrones in the (log $T_{\rm eff}$, log g) plane derived by Cester (1982).

Input values are just (m ; log $T_{\rm eff}$, log g), with their experimental errors, for the 2 component stars. The range of models, compatible with observational data and experimental errors, is determined by the *BOFER* code; so, the center of the range and its amplitude define the solution (Y_0, Z_0 ; t) and its accuracy, respectively.

Binary stars, satisfying our observational requirements, are not numerous: from the published catalogues (Popper, 1980; Andersen, 1991) and from other available material, only two dozens systems can be selected. In fact they should be *dwarf*, eclipsing systems (giving direct values of g and m), classified as *d–type* (no mass exchange). They should have *non–identical components* (2 distinct points on grid) with $\Delta m \geq 0.1\, m_\odot$, and moreover they must be *normal* binaries (no triple systems, RS CVn–types, Algols, etc.). Finally, good accuracy is required for the input data: errors on (m ; log $T_{\rm eff}$, log g) should not exceed (3%; 1%, 2%). Actually, admitted masses are from 0.9 to 3.6 $m_\odot$; extension is planned up to 25 $m_\odot$.

Due to the advanced stage of our computations, the results will become available in the immediate future.

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The initial idea of this method is due to B. Cester, who suggested the concept already in 1979. Two years later, the first numerical solutions were presented in a Thesis of one of the authors (Ferluga, 1981). The earliest version of the computer code (*BO-FER*) was written in collaboration with C. Boehm in 1983.

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