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The effect of the new opacities on the stellar models

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Abstract

In this study the effect of current opacities on the radii of stars is investigated. For this, the new OPAS opacity tables are adapted in Paczynski programs GOB(Generates the outer boudary), SCH, HB8 and applied to stellar models in the mass range of 0.6-10 $M_{\odot}$. In this work, the effect of the new opacity tables on the age of the observed real star U Oph is examined. The results are compared with the old opacity tables.

Keywords: *Stellar models, metallicity, new opacity tables.*

Yeni opaklıkların yıldız modellerine etkisi

Öz

Bu çalışmada güncel opaklıkların yıldızların yarıçapları üzerine etkisi araştırılmıştır. Bunun için yeni OPAS opaklık tabloları, Paczynski programları GOB (Dış sınır şartları oluşturmak), SCH, HB8'e uyarlanmıştır ve 0.6-10 $M_{\odot}$ kütle aralığındaki yıldız modellerine uygulanmıştır. Bu çalışmada, yeni opaklıkların gözlemlenen gerçek yıldız U Oph'un yaşı üzerine etkisi incelenmiştir. Sonuçlar eski opaklık tabloları ile karşılaştırılmıştır.

Anahtar Kelimeler: *Yıldız modelleri, metallik, yeni opaklık tabloları.*

1. Introduction

It is well known that opacity is quite complicated with all the sources. In stellar interiors, use of frequency averaged opacity is generally adequate such as the Rosseland mean [1]. In the outer layers of the stars the frequency dependence must be considered carefully. In the stellar interiors, main sources of opacity are due to bound-free transitions, free-free absorption and electron scattering [2] . Many researchers worked

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on opacity sources and calculations [3,4,5]. Inlek [6] constructed opacity tables for using in stellar modelling in a format particularly applicable to the Paczynski freeware program GOB. Tables are derived from those of Allard [7] and Weiss [8] for lower metal content envelopes.

OPAL and OP codes are known as theoretical methods for calculate opacities [9,4]. Many years ago opacity was identified [10,11,12]. Detailed explains of opacity are made by Inlek et al. [6] and by Inlek[13]. Inlek [13] showed that low metallicity opacities effect stellar radii. Metallicity dependence of envelope inflation in massive stars is studied by Sanyal et al. [14]. They have found that by opacity peaks of iron, helium and hydrogen stellar models develop inflated envelopes. Iron is the end of the fusion reactions in stars. It is known that the amount of iron/other metals determines the death of stars. e.g supernova, hypernova, black hole etc. Recently, Mondet et al. [15] have used OPAS opacity model to calculate Rosseland opacities for temperatures between logT=6(K) and logT=7.2(K). They have found that oxygen and iron have major contributions to the total opacity. Meanwhile Co contribution to mixture Rosseland opacity is very small in their calculations. The present work have used OPAS opacity tables of Mondet et al. [15] in Paczynski Codes [16] . We first formated OPAS tables by using four-point Lagrange interpolation for GOB, SCH and HB8 programs. Detailed description can be found in study of Inlek [6]. HB8 code of Paczynski uses results of SCH for making evolutionary stellar models. Methods have been developed to calculate opacities. We have constructed evolution for real star U Oph and derived age of system with different opacities. Recently Jin et al. [17] computed four sets of evolutionary models with convection and convective overshooting for massive stars over 10 $M_\odot$. They investigated the properties of the convective cores and convective envelopes of massive stars. For the future study on stellar models with over 10 $M_\odot$ is planned .

2. Results and discussion

In our previous study, the opacity tables are tabulated for different metallicity for Paczynski [16] codes. Their effects on stellar radii are discussed [6]. In the present paper we have used OPAS tables in GOB program. The results of GOB are used by program SCH. The SCH program creates the zero-age main sequence model where nuclear reactions begin where hydrogen in the core turns into helium. The program HB8 uses the output of GOB and SCH. HB8 changes the hydrogen and helium composition according to the regional nuclear reaction rates and time steps and creates an evolved star model. In this study it is derived radii for low-middle mass star models by using old opacity tables of Cox&Stewart and the new OPAS opacity tables. The Table1 includes results for radii. The Cox&Stewart opacity tables include Rosseland meaan opacities without allowance for electron conduction.

Table 1. GOB and SCH results for radii using OPAS tables

Parameter	Value						
MΘ	0.6	0.8	1	1.2	2.5	5	10
RB(Cox&Stewart)	0.3742	0.4633	0.5524	0.6162	1.0310	1.7319	2.3612
RB(OPAS)	0.3814	0.4638	0.5463	0.6120	1.0394	1.7613	2.3708
ROB(Cox&Stewart)	0.5816	0.6112	0.6408	0.7114	1.1710	1.9760	3.3940
ROB(OPAS)	0.6401	0.6861	0.7321	0.8735	1.7930	2.518	3.5141

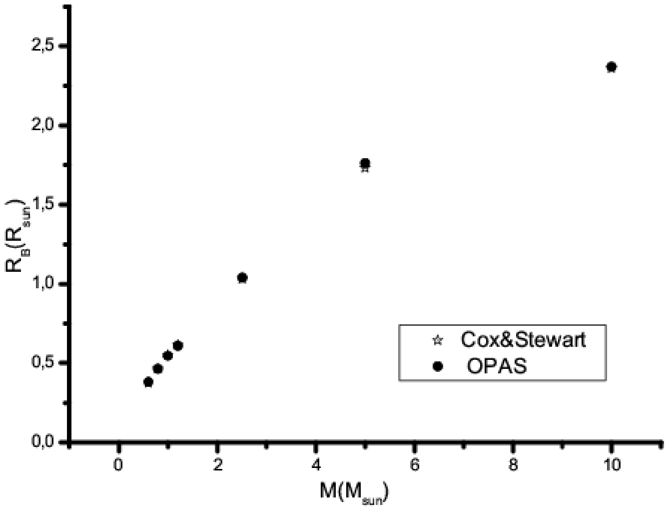

Figure1. Radii of GOB for different stellar models with opacity tables

Many years ago Schwarschild [2] presented 2.5, 5, and 10 solar mass models at zero age. He also presented 0.6 and 1 solar mass models. In this study 0.6, 0.8, 1, 1.2, 2.5, 5 and 10 solar mass models. RB, the base of atmosphere radius of GOB is calculted with old and new tables. ROB is the output of SCH. It is the boundary radius. Results are presented in Table1. It is clear that new tables give big radii than the old ones. OPAS tables give radii bigger than 2-5% the old tables. The new OPAS tables have greater effect on radius of massive stellar models than low mass models. Figure 1 presents the radii RB against mass with different tables. In the Figure2, SCH output radii ROB are shown. It is clearly seen that the effects of the new tables on ROB radii are bigger for high mass models. Generally lower metallicity acts like lower opacity. This effect tends to make the star with a lower zero age radius. So this will tend to increase the age of the stars. For the very young stars - like U Oph -hydrogen was used by the first generation of stars and some of it was converted to heavier elements. Hydrogen contents will go down while the metals would increase. We have estimated the age of system U Oph with different opacity tables. The results are presented in Table2. The new tables give the 5-10% increase in the age of system U Oph compared to the old ones. Results of this study are useful for check the derived ages of observed binary stars.

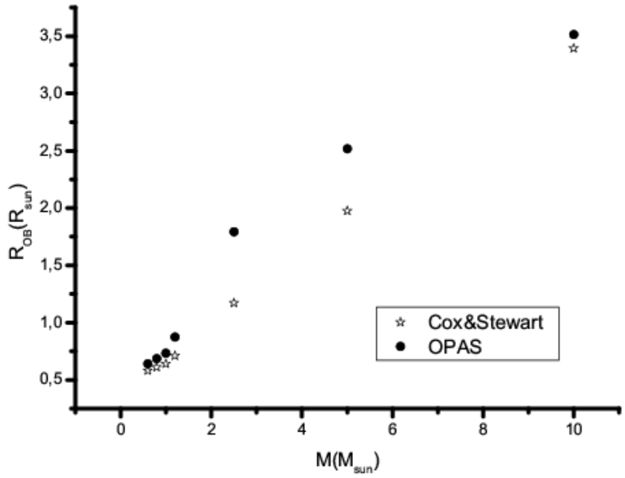

Figure2. Radii of SCH for different stellar models with opacity tables

Table2. Estimated Ages of U Oph with different opacities.

Cox&Stewart	26.145 My
Iglesias	26.895 My
Kurucz	28.615 My
Mondet	29.613 My

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