ON THE IMPORTANCE OF THE TRANSITION *Of* - *WN* STARS FOR THE UNDERSTANDING OF STARS WOLF – RAYET TYPE EVOLUTION

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The similarity of the properties *WR (WN)* and *Of* stars have been considered. The possible evolutionary connections between this group stars are investigated. It is proposed that there may exist nitrogen – rich *Of* stars. Five criteria for the determination of such objects are proposed. Nitrogen – rich stars are close to *WN7-8* stars at the evolution stage . Observation of nitrogen - rich *Of* stars is important for the understanding of *Of – WN7-8* evolutionary connection.

1. Statement of the problem.

The *Of* stars are the most luminous objects among *O* stars of early subtypes. More massive *O* stars are progenitors of *Of* stars. *Of* stars are located at the Main Sequence in the region corresponding to the highest temperature and luminosity. All *Of* stars are more massive stars. The presence of emission lines with profiles *P Cyg* in the *UV* and visible region in the spectra of the *Of* stars indicate that these stars lose mass. From the similarity of spectral properties of *Of* and Wolf-Rayet (*WR*) stars Conti [1] for the first time proposed the hypothesis that the *WR* stars had evolved by stellar wind mass loss from massive *Of* stars (scenario Conti), although this statement have not been investigated completely.

In the present paper, the probable evolutionary connections between *Of* and *WR* stars are considered, and some interesting results have been obtained.

2. The comparison of the spectral properties and evolutionary connection of *Of* and *WR* stars.

The *Of* stars are those *O* stars whose optical spectra display the presence of strong emission lines *NIIIλλ* 4634, 4640,4642 and *HeIIλ*4686. Other interesting spectral lines in the visible region in the spectra of the *Of* stars are *CIII λλ*4647-4651 and *CIIIλ*5696.

It is known that the *WR* stars have been divided into three spectral types [2]: *WN* stars which exhibit emission lines of dominantly *N* (*NIII-NV*) and He ions with little evidence for *C*, have been considered as *C*-poor objects; *WC* stars showing predominantly He and *C* lines and virtually no evidence for *N*, have been considered as *N*-poor objects; *WO* stars whose optical spectra display strong *OIV*, *OV* and *OVI* lines. According to [3] the spectra of WN *WO* stars reflect an actual enhancement of the abundance of oxygen, relatively to the *WC* stars. Authors of [3, 4, 5] proposed such an evolution scheme for the *WR* types:

$$WN \rightarrow WC \rightarrow WO \qquad (1)$$

Therefore the newly formed *WR* star is a *WN* star. It is known that for the spectral classification of stars *WN*4-9 subtypes were proposed [6]. These *WN*4-9 subtypes certainly represent different ionization conditions in the stellar wind of the *WN* stars. Various observational properties : luminosity, age, spectrum, *H/He* ratio, ionization structure of the envelope set *WN*7-8 stars clearly apart from other *WR* subclasses [7]. Namely this subtype of *WR* stars may be evolved by stellar wind mass loss from *Of* stars. The difference between *WN*7-8 and *Of* spectra is that in *WN*7-8 stars the emission spectrum is more developed, and that *WN*7-8 stars have higher mass loss rate and greater envelope density than *Of* stars. The emission line *HeIIλ*4686 is present in the spectra *Of* and *WN*7-8 stars, however this line narrower in *Of* stars than in *WN*7-8 stars.

The example for the transition object is star $-67^{o}22$ in the *LMC* with both *WN* and Of properties [8]. It is difficult to classify this star because the broad emission lines and Balmer series in absorption are visible at the same time. We would like to stress that the difficulty in classification of such objects may often be not the disadvantage of the classification system but rather the fact that one deals with stars which have only slightly different properties. Because of similarity of *WN* and *Of* stars they both even fitted in same early classification schemes before.

Although *Of* and *WN*7-8 stars have similar properties there are also differences between them. We may indicate five main differences between these stars:

1. In WN7-8 stars the nitrogen overabundance is easily seen [9]. But this statement has not been revealed for the *Of* stars obviously. If some *Of* stars truly become *WN*7-8 stars we must observe much close to *WN*7-8 the *Of* stars – nitrogen rich *Of* stars (*Of – WN*7-8 transition objects). We assume that these stars are more massive *Of* stars.

2. One of the basic correlations discovered by Beals [10] was the fact that emission lines in *WR* stars arising from ions of high ionization potential had much narrower widths than those of low ionization potential. This relation is more readily seen for the *WN* stars than for the *WC* stars because of line-blending.

It is important to verify validity of this correlation for the *Of* stars. We assume that this correlation takes place namely in the transition *Of* - *WN*7-8 stars.

3. Another property of *WN*7-8 stars distinctive from other stars is the *H/He* ratio. *WN*7-8 stars are *H* – poor objects, because of loss of *H* – rich envelope by stellar wind. Therefore the transition *Of – WN*7-8 objects must be the *H* – poor objects.

4. Another difference between *Of* and *WN*7-8 stars is the mass loss rate. The mass loss rate is higher for the *WN*7-8 stars than for the *Of* stars, therefore *WN*7-8 stars have more dense envelope.

5. The *HeIIλ*4686 is present in the spectra of the *Of* and *WN*7-8 stars. Widths of this line increase with the transition from *Of* to *WN*7-8 stars.

From 1-5 we may conclude that the spectra of the *Of* -

*WN*7-8 stars transition distinguish from those *Of* and *WN*7-8 stars by the degree of emission line strength, they also have different envelope densities and mass loss rates. We think that the evolution from *Of* type to the *WN*7-8 is gradual and not dramatic. Stellar wind mass loss rate and chemical mixing can explain such behavior. Therefore we may give more exact evolution scenario for the evolution of *WR* stars subtypes:

$$O \rightarrow Of \rightarrow WN7\text{-}8 \rightarrow WN\ early \rightarrow WC \rightarrow WO \quad (2)$$

3. Conclusions

1. Some massive *Of* stars by stellar wind mass loss may gradually evolve into *WN*7-8 stars.
2. There must be the *Of* - *WN*7-8 stars transition with five properties indicated above. The spectral properties of these stars must be intermediate between those of *Of* and *WN*7-8 stars.
3. Observation and investigation of the *Of* – *WN*7-8 stars transition are important for the understanding of the evolutionary connection between *Of* and *WR* stars.

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Of - WN KEÇİD ULDUZLARININ VOLF-RAYE TİPLİ ULDUZLARIN TƏKAMÜLÜNÜ ANLAMAQ ÜÇÜN VACİBLİYİ HAQQINDA

Of və Volf-Raye ulduzlarının spektral xüsusiyyətlərinin oxşarlığı araşdırılmışdır. Bu ulduzlar arasında mümkün təkamül əlaqələri tədqiq olunmuşdur. Azotla zəngin olan *Of* – *WN*7-8 keçid ulduzlarının mövcudluğu haqqında hipotez irəli sürülmüşdür. Bu ulduzlar təkamül nöqteyi nəzərincə *WN*7-8 ulduzlarına yaxın olmalıdır. Azotla zəngin olan *Of* ulduzlarının müşahidəsi *Of* – *WR* təkamül əlaqələrini başa düşmək üçün mühüm əhəmiyyət kəsb edir.

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О ВАЖНОСТИ ПЕРЕХОДНЫХ *Of- WN* ЗВЕЗД ДЛЯ ПОНИМАНИЯ ЭВОЛЮЦИИ ЗВЕЗД ТИПА ВОЛЬФА - РАЙЕ

Проанализировано подобие спектральных особенностей *WR(WN)* и *Of* звезд. Исследованы возможные эволюционные связи между этими объектами. Предложена гипотеза о возможности существования *Of* звезд с обилием азота. Предложены 5 критериев для выявления этих объектов. Эти объекты эволюционно могут быть близки к *WN*7-8 звездам. Выявление этих объектов является важным обстоятельством для понимания эволюционных связей между *Of* и *WN*7-8 звездами.

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