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THE O2–O3 STARS PRESAGED IN THE BOLETÍN DE LOS OBSERVATORIOS DE TONANTZINTLA Y TACUBAYA

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RESUMEN

A continuación de una anécdota personal irrelevante y algo graciosa que involucra al Boletín, se comentan dos trabajos publicados allí que son relevantes al descubrimiento de las estrellas de alta temperatura más masivas, de tipos espectrales O2–O3, y se relacionan con los desarrollos subsiguientes de ese tema.

ABSTRACT

Following an irrelevant, mildly humorous personal anecdote involving the Boletín, two papers published there that are relevant to the discovery of the most massive hot stars, of spectral types O2–O3, are noted and related to subsequent developments in that field.

Key Words: H II regions — stars: early-type — stars: fundamental parameters

1. AN ANECDOTE

My first encounter with the Boletín de los Observatorios de Tonantzintla y Tacubaya occurred shortly after my arrival in 1966 at the Yerkes Observatory of the University of Chicago to begin my graduate studies. Being energetic, ambitious, and conscientious, along with my initial astronomical studies I immediately undertook to pass the two language requirements for the PhD, by policy to be selected from French, German, or Russian (As a further stimulus, there was a senior student in residence at that time who had completed all of the requirements for the degree six months earlier, except for the Russian test...). Since I had studied German during my last two years in college, I quickly disposed of that one before forgetting what little I knew. Then, contrary to the advice and expectations of the faculty, I applied to the dean for authorization to do my second requirement in Spanish (in which I had been fluent since the age of nine). I spared no specious argument, including the observatories in Chile and the Boletín (hoping that he wouldn't look and see that many of the articles were in English!). To the amazement of the professors, my unprecedented request was granted, and of course I passed that one easily. Then, during my second year, the language requirements for the PhD were abolished. From which I learned the moral, "never do today what you can leave for tomorrow", which I have practiced faithfully ever since.

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2. THE CARINA NEBULA

My next encounter with the Boletín, although actually astronomical, also began rather inauspiciously. Two years later, I was in the fortunate position of undertaking my thesis under the direction of W.W. Morgan. He was always concerned about the status and stature of the MK system, to the eternal benefit of astronomy and astrophysics. One of his specific concerns at that time was the relationship, or rather lack thereof, between spectral classification in the northern and southern hemispheres – the practitioners, instruments, and methodologies being fairly disjoint. An outstanding issue was, of course, the standards that define the system. Morgan's plan to address that problem was to observe equatorial objects from the south, and then use those data to establish new, deep southern standards with the same instrument, especially in the Milky Way for the early-type stars. Because of the remarkable objective-prism study of the Carina Nebula ionizing clusters by Münch & Morgan (1953) with the Tonantzintla Schmidt (observer G. Haro, zenith distance $78^{\circ}\!.5$ on the meridian!), he was well aware of that field as a potentially rich source of standards. Indeed, that was his first idea for my thesis. But then, as was his wont, he had second thoughts about the risk to his grants of sending an unproven student that far, so my topic was changed to a less costly northern project. Fortunately, I was able to accomplish that to his eventual satisfaction, so I was retained for a three-month postdoctoral appointment immediately following the completion of my degree and sent on my first mission to the Cerro Tololo

Inter-American Observatory, to pursue the original objective.

Well, the brighter stars in the Carina Nebula clusters turned out not to be very good transfer standards, because their spectral types were earlier than those of the earliest MK standards at the time! The O4 spectral type, introduced by Morgan et al. (1965) and Abt et al. (1968), was defined by HD 46223 in the (near equatorial) Rosette Nebula. The primary horizontal (temperature) criteria for the O stars are the ionization ratios of helium lines. The stronger He I lines were weak but well defined at type O4 in optimum photographic spectrograms of the time, but they could not be discerned in the spectra of several of the Carina stars, which were thus classified into the new O3 category (Walborn 1971, 1973). One of them, HD 93129A, also had He II λ4686 in emission and was thus of type Of, but with N IV emission and N V absorption lines of unprecedented strength, much greater than in O4f spectra such as that of HD 190429A. That is, all indications were that HD 93129A had a higher effective temperature than any seen previously among massive stars, and thus likely also a higher mass. Moreover, a clear morphological and likely physical sequence of envelope development could be inferred from the O3 V spectra, through the O3f, to the three luminous, narrow-lined WN stars also in the Carina Nebula. This was the first recognition of an evolutionary sequence subsequently developed by Walborn (1974), Conti (1976), and Langer et al. (1994). It is quite possible that η Carinae itself is the (near) endpoint of that sequence. Indeed, because of its relatively small distance and reddening, and its rich stellar population, the Carina Nebula is the most accessible laboratory for investigation of the most massive stars, as was likely suspected by Münch & Morgan (1953).

3. PISMIS 24

From a growing sample of high-S/N digital data, the original O3 spectral type was later subdivided into O2, O3, and O3.5 by Walborn et al. (2002), primarily on the basis of the N IV to N III emission-line ratios. Two high-luminosity examples of the O3.5 type had been found by Massey et al. (2001) in the remarkable small cluster Pismis (1959) No. 24, which ionizes a sub-region of the large NGC 6357 H II complex, and is triggering new star formation in and around a spectacular adjacent pillar structure (Wang et al. 2007). This important cluster entered modern lists from the original paper through the photometric study of Moffat & Vogt (1973).

However, one of these O3.5 stars, Pismis 24–1, was rather annoying, because its photometric properties implied an evolutionary mass between 200 and 300 $M_\odot$, uncomfortably larger than the $\sim$150 $M_\odot$ limit emerging from numerous studies of massive stars and clusters. Fortunately, that discrepancy has now been resolved by a combination of *Hubble Space Telescope* imaging that split Pismis 24–1 into a $0\farcs4$ double (Maíz Apellániz et al. 2007), and ground-based photometry that reveals one of the components as a 2.36 d eclipsing binary (Massey, private communication). So, rather than being one 300 $M_\odot$ star, Pismis 24–1 is three 100 $M_\odot$ stars, and all is well with the upper mass limit! And of course, this multiple system and cluster are outstanding objects for further investigation of the formation and early evolution of the most massive stars.

4. CONCLUDING THOUGHTS

Retrospective considerations can provide interesting and useful philosophical as well as historical insights. One sees how knowledge and understanding progress from fundamental beginnings to ever higher levels, as instrumental and interpretational capabilities develop. Also, an observer may feel encouraged that basic data, carefully obtained and presented, will usually contribute to subsequent developments quite beyond what might have been originally conceived.

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