1971 REVISITED; FOSSILS, ALIVE AND DEAD

An historical introduction

LINDSEY F. SMITH
School of Physics, University of Sydney, NSW 2006
mail address: 6B-26 Etham Ave, Darling Point, NSW 2027, Australia

There are two eras of Wolf-Rayet research; pre-1971 when I was most active, and post-1971 when most of you entered the field. I have been in this game on and off for 32 years; that's since before many of you were born. Karel and I were noticing at breakfast that I am about the last of the remaining nearly-fossils, the generation that were active in the field up to 1971 when the second WR conference (IAU Symposium No. 49) took place in Buenos Aires. That conference marked a total paradigm shift and I would like to take a few moments to remember significant contributors to that paradigm shift who are not with us today.

The first I would like to remember — because he is not with us permanently — is Karl Henize who died climbing Mount Everest last year. I met Karl first when I was a graduate student. He did a search for emission line objects in the Magellanic Clouds (Henize 1956). Nebulae and stars with a discovery name 'He' were found by him. He was always a little larger than life, whether it was being a boxer in South Africa, before I knew him, or leaping from the 74-inch telescope platform to the ground or wiping out the platform by running it into the telescope. It is characteristic of Henize that he was climbing Mount Everest at the age of 63. It shows the same spirit that made him an astronaut. He was prepared to go where most of us do not quite dare. He was gentle, honest and respectful and that is perhaps the most important thing you can say about a person. I miss him here today.

Other players who made significant contributions and then left the field include first Morton Roberts (who is alive and well and I saw him last week at Space Telescope Science Institute). Roberts compiled the fourth catalogue of Galactic WR stars in 1962 and noted that there was a difference between the distributions of WR and O stars. Westerlund (& Smith 1964) searched the Magellanic Clouds for WR stars, while I was his research assistant, and then generously allowed me to take them as my Ph.D. topic.

Up to this point the WR stars were considered strange, rare and totally not understood. People, most notably Anne Underhill (*e.g.*, 1960a), had made intensive studies of individual stars but there was nothing comprehensive. I set out to discover their overall properties as a class, spectroscopically and photometrically, discovering amongst other things the extraordinary gradient of subtypes in the Galaxy and differences between the Galaxy and

K. A. van der Hucht and P. M. Williams (eds.), Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution, 3–6.

the Magellanic Clouds. At the same time, Len Kuhi (1966) at Berkeley was doing absolute photometry on the continuum and emission lines — a job that was difficult then, in marked contrast to what is possible now.

Also at the same time, Kippenhahn & Weigert (1967) were doing evolutionary models of binaries with mass transfer. Kippenhahn drew to my attention a short paper by Bep Paczynski (1967) in *Acta Astronomica* in which he reported calculations for a low mass pair; he suggested that the resulting pure helium star might look like a WR star if the mass were high enough. I was immediately sure that he was correct; proving it, against stiff opposition, took a few years. Kippenhahn ran a mass exchange model starting with a 25 $M_\odot$ primary arriving at a 10 $M_\odot$ pure helium star with a wisp of an atmosphere still containing some hydrogen (reported by Smith 1968). Paczynski (1967) also pointed out that a pure helium star of this mass is unstable to the ϵ-mechanism (Boury & Ledoux 1965). I believe this will yet prove to be a relevant property of the WR stars.

The next big step forward happened because of Dick Thomas (who I assume is alive and well because, otherwise, I would have heard about it). He had always been interested in WR stars. He convened the first conference in Boulder in 1968 (Gebbie & Thomas 1968) and then assembled a think tank at JILA to attack the problem. He brought in me, Len Kuhi and Bep Paczynski. We brainstormed for a year with the locals, John Castor, David van Blerkom and Dave Hummer. The biggest thing which came out of that brainstorm was the fact that we could determine the helium abundance from the Pickering decrement. Len and I were working on the WR Atlas, half of which eventually made the light of day in 1981. Castor and van Blerkom (1970) did then-best possible theoretical study on HD 192163, using the Atlas data. Hummer was there assuring us that the *bn* and recombination rates as a function of temperature were the same for H^+ and He^{++}.

I completed the WN segment of the Atlas over the next 2 years and was able to take the results of H^+/He^{++} measurements for all subclasses to the 1971 conference (Smith 1973a), showing that, as a class, the WN stars are pure helium stars. The first UV spectrum of HD 50896 with *OAO-1* eliminated the conjecture that the difference between the WN and WC stars might be due to excitation effects only (*e.g.,* Underhill 1960b). Knowing that WR were pure He, He-burning stars, the relative numbers in the Galaxy showed that, far from being rare objects, they were a short phase in the evolution of essentially all stars over 25 $M_\odot$ (Smith 1973a).

Bep Paczynski (1973), in the discussion after his review paper, reminded us that the *pp*-cycle converts most of the primordial C to N. To get C back into the atmosphere, the C must come from He-burning and be mixed to the surface or the remaining shell of nitrogen containing material has to be shed. Either way, the transition is from WN to WC and is very rapid; the WC stars will have no hydrogen. The observational evidence against H in

the WC spectra (Smith 1973b) was strong.

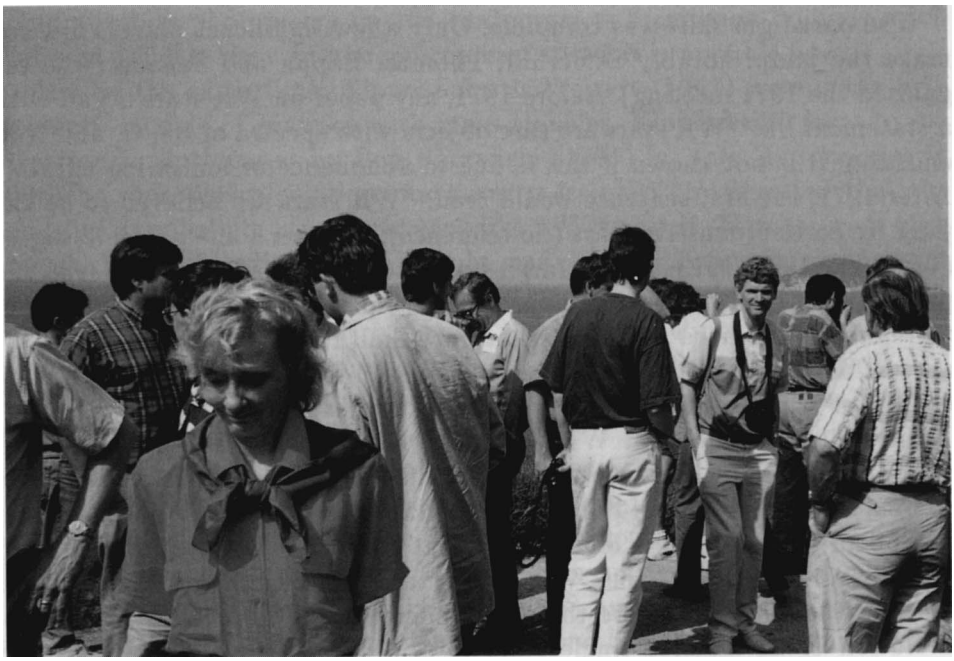
The paradigm shift was complete. Only a few significant players did not make the jump: notably Underhill, Thomas, Bappu and Sahade (who organised the 1971 meeting). Before 1971, any paper on WR stars began with a statement like "WR stars are rare objects with spectra of He, C, and N in emission; it is not known if this is due to abundance or ionisation effects". After 1971, the first sentence would read: "WR stars are believed to be the pure He cores of massive stars (no reference); however some people disagree (Underhill 1972, 1973, 1974, ...)". I am proud that my work achieved the paradigm shift. However, it is appropriate (especially when there is dissent) to reference the hard evidence in favour (Smith 1973a,b; Paczynski 1973) as well as against the dominant view. We can do better than "science by consensus"; and even fossils appreciate acknowledgement.

In 1971, we knew that WR were pure helium stars; we knew we could make such a star by binary interchange. This was before mass loss was known to be a significant part of the evolution of all massive stars. We wondered if maybe all WR stars were binaries. At that point, all the key players moved off into other fields and the "WR as He stars" era began with a new team.

Over the 10 years before the next conference (de Loore & Willis 1982), evolution of all massive single stars to a WR phase was established and various "channels" proposed. Now we again have a conference focussing on WR as binary stars. The path of knowledge is often a spiral; we revisit old domains with more knowledge and discover new relevance. May it be so with this conference.

References

Boury, A., Ledoux, P. 1965, *Ann.d'Ap.* **28**, 353
Castor, J.I., van Blerkom, D. 1970, *ApJ* **161**, 485
de Loore, C.W.H., Willis, A. 1982, Wolf-Rayet Stars: Observations, Physics, Evolution, *Proc. IAU Symposium No. 99* (Dordrecht: Reidel)
Gebbie, K.B., Thomas, R.N. 1968, Wolf-Rayet Stars, NBS Special Publication 307
Henize, K.G. 1956, *ApJ Suppl.* **2**, 315
Kippenhahn, R., Weigert, A. 1967, *Zs.f.Ap.* **65**, 251
Kuhi, L.V. 1966, *ApJ* **143**, 753
Paczynski, B. 1967, *Acta Astr* **17**, 355
Paczynski, B. 1973, in: M.K.V. Bappu & J. Sahade (eds.), Wolf-Rayet and High Temperature Stars, *Proc. IAU Symposium No. 49* (Dordrecht: Reidel), p. 143
Roberts, M.S. 1962, *AJ* **67**, 79
Smith, L.F. 1968, in K.B. Gebbie & R.N. Thomas (eds.), Wolf-Rayet Stars, (loc.cit.) p. 23
Smith, L.F. 1973ab, in: M.K.V. Bappu & J. Sahade (eds.), Wolf-Rayet and High Temperature Stars, *Proc. IAU Symposium No. 49* (Dordrecht:Reidel), p. 15 and p. 228
Smith, L.F., Kuhi, L.V. 1981, An Atlas of WR Line Profiles, JILA Report No. 117
Underhill, A.B. 1960a, *ApJ* **136**, 14
Underhill, A.B. 1960b, in: J.L.Greenstein (ed.), Stellar Atmospheres (Univ. of Chicago Press), p. 428
Westerlund, B.E., Smith, L.F. 1964, *MNRAS* **128**, 311



Lindsey Smith and the community at large

https://doi.org/10.1017/S0074180900201496 Published online by Cambridge University Press