## GENERAL DISCUSSION

Van Blerkom: Quite a point was made of the binary nature of the WR stars in the SMC. I'd like to ask, Peter, what's the significance of this?

Conti: Let me give the following speculative possibility. We know the SMC is deficient in CNO elements with respect to the Galaxy. If stellar winds are driven primarily by radiation pressure from CNO lines themselves, then perhaps winds would be weaker in SMC stars of similar type compared to Galactic stars. Maybe it would then be possible to evolve massive stars to WR types only in binary systems, unlike in our Galaxy where single WR stars can evolve from massive O stars by stellar wind mass loss.

Hutchings: Our optical spectra of some SMC O and Of stars show them to be like galactic ones, hence the winds are similar, and the evolution would be similar.

Conti: It sounds like my speculation didn't make it beyond the first rejoinder, but I prefer to wait for U.V. spectroscopy where the winds are observed directly.

Crampton: I'd like to ask Dr. Breysacher again about the SMC stars. You indicated that you only inferred the presence of companions for WN3, 4, 5 stars in the SMC by their higher luminosity in some cases. Is that correct? If so, then perhaps the frequency of binaries in the SMC and the Galaxy is not too different since in the Galaxy we do not know the luminosity and hence cannot infer binary nature.

Breysacher: Yes, namely for stars SMC/AB4, 5 and 7 of Table 1 no absorption lines are seen and the binarity is inferred from the strength of the continuum and the absolute magnitudes. I am also aware of the fact that some WN stars show absorption lines themselves and would like to ask Dr. Niemela if these are hydrogen lines only.

Niemela: Hydrogen and He II absorption lines are seen in several Galactic WR stars. Many are composite spectra, but in some cases the absorptions in fact arise in the WR star itself. This is to be discussed later in this Symposium (Sessions 5 and 8). I don't know that the $M_V$ are all that well known for WR stars, however.

Conti: I have been looking into this and will report more fully in Session 8. But for now let me say the following: The $M_V$ calibration for WR stars is primarily based on LMC stars (Smith, M.N. 1968). The "single" early WN stars (i.e., no absorption lines) have $M_V \sim -4$ to $-5$. A number of early WN stars are considerably brighter but without exception all have absorption lines, presumably due to a companion. In our Galaxy, we now know of some later type WN stars to have intrinsic absorption lines, as we shall see. But then, maybe these bright early-type WN stars in the SMC (and LMC) are not composite either but single



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stars. That would be even more interesting. They have not been studied in detail as yet.

Underhill: I'm still worried that many of those early WN stars discussed by Breysacher are unresolved doubles, where the O star dominates the continuum and contributes.

Conti: Nolan Walborn would have made this same point had he been able to attend this meeting. He has pointed out a few cases of O subgroups in the LMC that become resolved at the 4-meter telescope which were previously only "fuzzy" at lower resolution.

Hutchings: I have obtained slit spectrograms of one of these O-WN stars in the SMC -- R31. The absorption lines vary by 100 km $s^{-1}$ so it is clearly a binary.

Vreux: I would like to ask Ann Underhill why, if there is another star by chance in the line of sight to SMC WR stars, it's an O star rather than, say, an A type?

Underhill: That's easy. The luminosity you need to see absorption lines against a WR star means $M_V$ must be of the same order, $\sim -4^m$ to $-5^m$. This corresponds to an O type; an A type would be completely invisible.

Crampton: A better argument might be that those groups usually are made up of O types, not A types.

Van den Heuvel: 30 Doradus is perhaps a good example of this. It's made up of five or so stars.

Leung: I would like to comment on how binary systems might end up as contact systems. Recent calculations (Flannery, Ulrich, Burger) taking into account the mass accreting components suggest that further evolution of semidetached systems lead to contact systems. The following slides illustrate this point quite well. The configuration of BF Aur represents a stage before the mass ratio reversal; μ'Sco represents a stage after the mass ratio reversal; and SX Aur represents a stage where a system is approaching a contact configuration.

Niemela: Can you use a Roche model alone; shouldn't you take into account the radiation pressure force the equipotentials in such luminous stars?

Leung: I think this is all right for B stars.

R. E. Wilson: The important point is how close the luminosity is to the Eddington limit. We will hear about this later in one case (UW CMa). However, for most systems, I feel this isn't important.

Bidelman: I'd like to ask John Hutchings the following: What is the duplicity situation in the extreme Of stars? Also, do you consider +40°4220 an extreme Of star? It has at times strong hydrogen emission.

Hutchings: Several stars, HD 151804, HD 152408 and HD 148937, do appear to be single [Conti, Garmany and Hutchings, Ap. J. (1977)]. I am not familiar with BD+40°4220.

Crampton: In connection with mass loss I would like to call attention to one nebula, NGC 6334, described by Dr. Pismis, which contains four nebular concentrations. Three are normal H II regions, but one looks very much like the ring nebulae that contain WN stars and may in fact be the result of mass loss from the WR stars. However, this nebula, which looks like NGC 6888, has two central O type stars which appear to be completely normal.

Lamb: I'd like to ask Dr. Pismis what evidence is there that the material in the ring is ejected, rather than swept up interstellar material?

Pismis: Essentially, the symmetry of form and the structure of the velocity field. For details, see the references in the text.

Abbott: If one believes that these WN stars are evolved from massive O-stars then the wind from the progenitor star would have evacuated a large cavity around the star -- an interstellar bubble -- leaving no material to be swept up. Thus, ring nebulae are probably ejected rather than swept up.

Pismis: I still worry about the hypothesis of spherically symmetric stellar winds. Some material probably is swept up but most of what we observe in the rings was ejected non-isotropically.

Kwok: I would like to offer the following speculative argument. If these WN central stars have evolved from O stars, they may have been red supergiants in between these phases. During the red supergiant phase a low velocity wind could have carried away an appreciable fraction of stellar mass. Then when the WR star develops, it has a high velocity wind. The ring could be the shock phenomena associated with this rapidly moving wind colliding with the red supergiant ejecta.

Underhill: A really fundamental problem in physics is the ubiquitous appearance of stellar winds, and their energy input, in stars of many spectral types, not just O and WR stars.