THE VELOCITY FIELD OF S308. THE RING NEBULA AROUND THE WN 5 STAR HD 50896

Paris Pişmiş and Alfonso Quintero
Instituto de Astronomía, Universidad Nacional Autónoma de México.

ABSTRACT. Radial velocities are determined by Fabry-Pérot interferometry at 131 points of the ring nebula S308. The velocities have yielded a kinematic distance of 1.5 kpc for the object, and an expansion velocity of 45-60 km s^{-1}. The ring nebula has a diameter of 13 pc and the age is estimated to be about 1.5 to 2×10^5 years.

The galactic H II region S308 is considered to be a "ring" nebula. On Palomar Sky Survey red plates it is composed of wisps arranged along half a ring of about 16 arcsec radius centered on the WN5 star HD 50896, hence its classification as a ring nebula. Johnson (1971) has been able to trace the ring with a radius of 15.5 arcsec in his observations at 5010 MHz with the 140-foot antenna at NRAO and has estimated the mass of S308 to be 5 $M_\odot$. Our photographs in the Hα line (10 A halfwidth) of the object exhibit continuous faint filaments joining the wisps.

We have attempted to obtain the velocity field of S308 in the past few years. The nebula is rather faint for our equipment, however observations in February of this year have yielded measurable material, the results of which are presented below.

Our observational material consists of five interferograms obtained using a Fabry-Pérot interferometer attached to the Cassegrain focus of the 1-meter reflector at Tonantzintla Observatory. The étalon has a free spectral range of 283 km s^{-1} at Hα, which is isolated by a 10 A interference filter. The interferograms are recorded on 103-aG films through a one-stage Varo image intensifier, and the measurements carried out on the Mann measuring engine at the NASA Johnson Space Center.

The five interferograms have yielded radial velocities at 131 points. A number of interference rings have shown duplicity. The velocity difference at these positions is attributed to the expansion of a shell of matter ejected by HD 50896. The average heliocentric

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radial velocity of the 131 points measured on all five interferograms is 40 km s^{-1}±15 (standard deviations) and this we have adopted as the systemic velocity of S308. The average velocity from the double points is 41 km s^{-1} in good agreement with the above value. The kinematic distance of S308 (assuming it to be a Pop I object) using the Schmidt rotation curve is estimated to be 1.47 kpc (1.59 kpc if we use V= 41 km s^{-1}). This is comparable to the photometric distance of 1.59 kpc given by Smith (1968). The distance from the galactic plane of S308 is

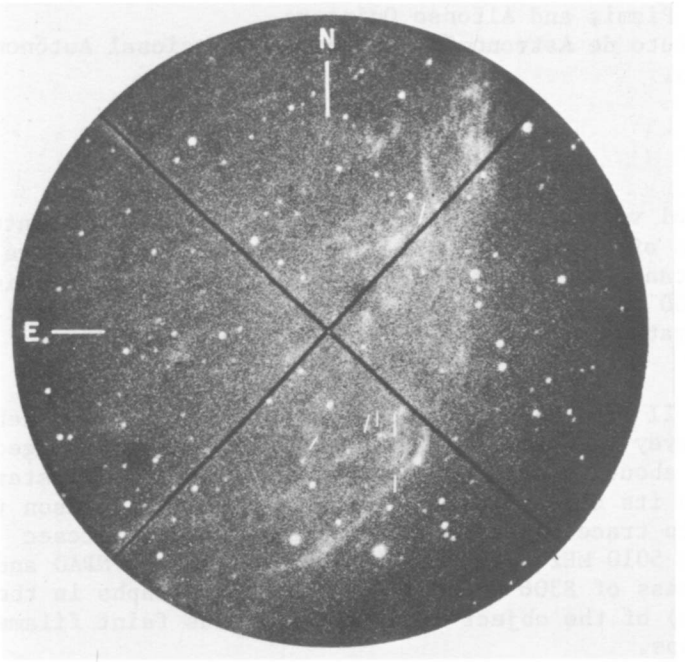

Figure 1. Enlargement of a direct photograph taken with a focal reducer attached to the Cassegrain focus of the 1-meter reflector at Tonantzintla Observatory, through an Hα, 10 A interference filter and a one-stage Varo image intensifier. The regions where duplicity of the interference rings were observed are marked by segments, the lengths of which are proportional to the velocity difference of the double rings.

therefore 258 pc and the linear radius of the shell, 6.8 pc.

The seven regions where duplicity of the interference rings was considered as certain are marked on the photograph in Figure 1. The segments are proportional to the velocity difference at the two extremities of the segments. These velocities are the projections in the line of sight of the difference of the observed velocities if indeed there is a radial expansion. The position of the points with respect to the periphery of S308 has to be known in order to obtain

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the projection angle and hence the velocity of expansion. Figure 2 is a collage of four direct photographs in Hα taken with a focal reducer and a Varo image intensifier coupled with the 1-meter reflector at Tonantzintla Observatory. We have made an estimate of the projection angle of the double points from this collage. The average expansion as estimated from these seven regions yields 45 km s^{-1}. The uncertainty is large since the periphery of the nebula cannot be unambiguously determined.

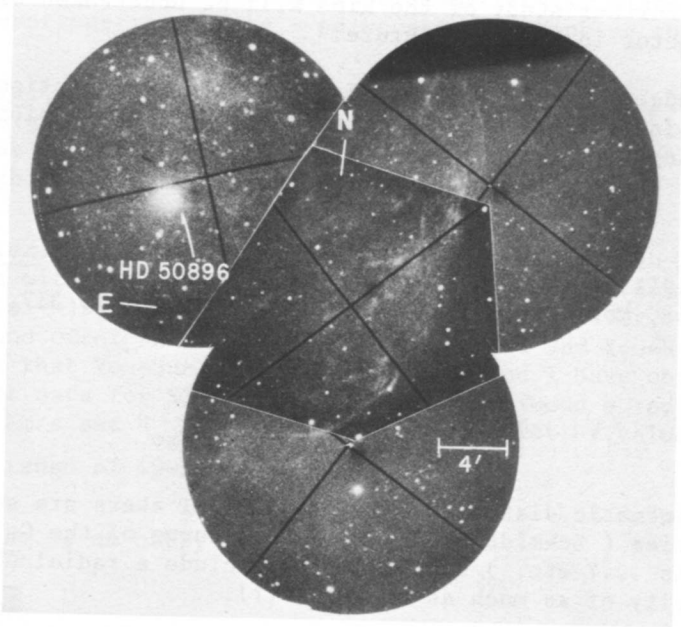

Figure 2. A collage from four direct photographs of S308 taken with the equipment as in Figure 1.

An idea of the age of the expansion can be had using these tentative values; with an overall expansion velocity of 45 km s^{-1}, a radius of 6.8 pc will be described by the ejected matter in 1.5×10^5 years. This is a provisional value on at least two accounts (a) ejection velocity at the earlier stages will certainly be larger being nearer the attraction center, the star, even if the expansion velocity may not be affected by the interstellar matter, which at a distance of 258 pc from the galactic plane should not be appreciable and, (b) the periphery of the nebula may be closer to the measured double points, hence the radial expansion velocity in reality maybe larger than 45 km s^{-1}, perhaps more nearly 60 km s^{-1}, bringing upwards to 2×10^5 the expansion age of S308.

The location of HD 50896 at the geometric center of the ring of

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S308 is striking. This implies that the nebula and star have been moving together. On the other hand, the nebula has a velocity comparable to a circular galactic orbit. This rules out the suspicion that HD 50896 is a runaway star.

We have presented above a preliminary study of the velocity field of S308, and the consequences thereof are only true in order of magnitude. Despite the tentative nature of our results, the estimated age and the dimensions of S308 are quite comparable to other ring nebulae in our Galaxy. Further study of the kind will be undertaken with our 2.12 meter reflector in the near future.

We acknowledge the assistance of I. Hasse in the reductions. One of us (P.P.) is indebted to the NASA authorities for permission to use the Mann measuring engine at the J.S.C.

References

Johnson, H.M.: 1971, Astrophys. J. 167, 471.
Smith, L.F.: 1968, Monthly Notices Roy. Astron. Soc. 141, 317.

DISCUSSION

Moffat: Kinematic distances of extreme Pop I stars are subject to large uncertainties (Schmidt or flat rotation curve of the Galaxy, streaming motions ...? etc.) so one cannot exclude a radial component of runaway velocity of as much as ~ 20 km/s (?).

Pismis: As you said the kinematic distances of extreme Pop I stars are subject to large uncertainties. I should add that uncertainties also exist for any population. A flat rotation curve appears now to be better that the Schmidt curve which I have used in the distance determination. However, the galactocentric distance of the nebula is around 10.2 pc. At this distance the deviation of the Schmidt curve from the flat curve is inappreciable. As to random motions etc., a radial motion of 20 km/s will not quite make HD 50896 a runaway object.

Rosado: I would like to comment about the spherical symetry of this nebula and the possibility of the runaway WR star. Given that the age is large enough, if the star is nearly at the centre and the nebula is spherically symetrical, it is hard to believe that the WR star has high velocities because in that case the nebula would be distorted (as in the model of SSSW driven nebulae of Weaver et al. 1977, Ap.J., 218, 377), and the star would not be at the centre of the nebula.

Pismis: I have emphasised clearly enough that the systemic velocity of the nebula we estimated is normal for its galactic position, hence the parent star is not a runaway object.

Smith,L.F.: I missed the previous remark about symetry of the nebula, so I don't know if I am agreeing or disagreeing. If the material in the ring nebula is material lost by the present WR star in the process of becoming a WR star (as I suggested: Wendker et al., 1975, A&A, 42, 173),then it is shed when the system is already a runaway and there is no expectation that the star will be asymetrically placed in the nebula (okay - everyone is nodding - so we are all thinking the same way !).

Pismis: Indeed HD 50896 is at the centre of the ring nebula. Since it is nearly 250 pc from the galactic plane there will be no worry about braking due to interstellar matter; the nebula is well outside the IS layer which is not likely to extend beyond 100 pc.

Kwitter: I have a slide and a comment. Here is an (OIII) photo of S308 taken with the Schmidt at CTIO. You can see the complete shell with radius ~15 arcmin. The other frame shows a wider view and you can see a second outer shell, as found by Ted Gull and You-Hua Chu. My comment is that You-Hua Chu, Dick Treffers and I have obtained scanning Fabry-Perot data for S308 in (OIII) and have found a radial velocity of v_{LSR} = 33 km/s and $V_{expansion}$ = 60 km/s. The latter value is consistent with your range of 40-60 km/s.

Pismis: I am happy to hear that.

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