

38. REFLECTION NEBULAE AND SPIRAL STRUCTURE

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Abstract. It is shown that stars embedded in reflection nebulosity may be used as spiral-arm tracers.

Surveys of stars embedded in reflection nebulae (Dorschner and Gürtler, 1964, 1965; Van den Bergh, 1966) show that reflection nebulae occur in associations. A detailed photometric and spectroscopic investigation of these associations of reflection nebulae has been carried out by Racine (1968, 1970). Some R associations coincide with known OB associations, others are connected with groupings of T Tauri stars and some are located in regions in which star formation was not previously known to occur.

Racine (1968) and Van den Bergh (1968) were able to show that R associations outline the Orion spiral arm rather better than do OB associations. The reason for this is that the number of R associations per kpc^2 in the galactic plane is greater than is the number of OB associations. This is so because the late B and early A stars, that dominate the stellar content of R associations, have a much greater space density than do the O and early B stars which populate OB associations.

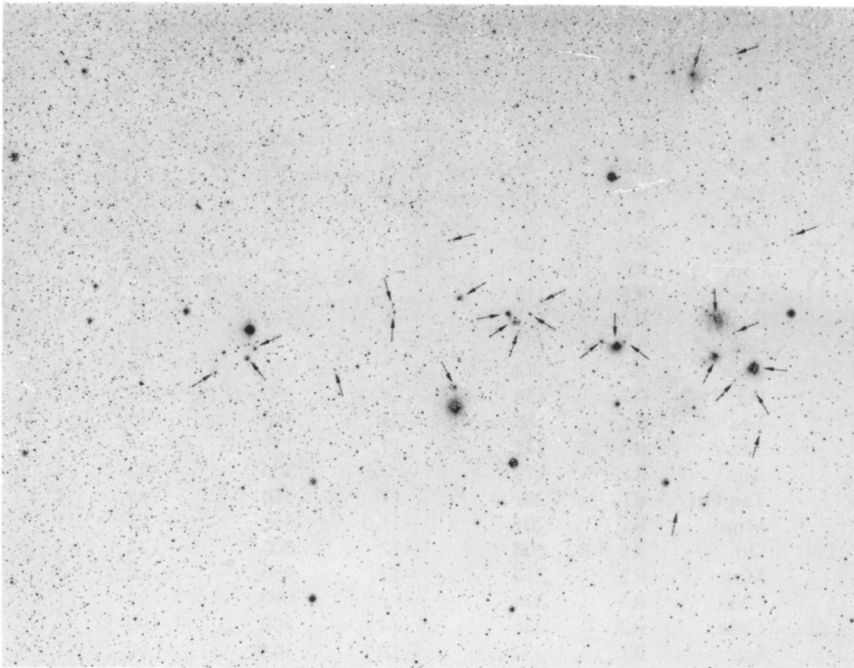


Fig. 1. Mon R 2 is a good example of an association of reflection nebulae. The earliest spectral type in this R association is B1. The distance of the association Mon R 2 is 950 pc.

A good example of an association of reflection nebulae is shown in Figure 1. In the figure 27 members of the association Mon R 2 are identified. This association, which contains both early and late B stars, is located at a distance of 950 pc.

Table I lists the associations of reflection nebulae that have so far been studied in detail. The positions of these R associations are plotted in Figure 2. The figure shows that associations of reflections nebulae outline the Orion spiral arm rather well. Figure 2 shows that this arm extends from $l^{\text{II}}=70^\circ$ to $l^{\text{II}}=250^\circ$. In the direction $l^{\text{II}}=160^\circ$ (Perseus-Auriga) the principal axis of the Orion arm, as outlined by reflection nebulae, is located at a distance of approximately 250 pc from the sun. Comparison of Figure 2 with plots of the distribution of clusters, OB associations and HII regions (Becker, 1964) shows excellent agreement between the spiral arms outlined by R associations and those obtained by other methods. The apparent lack of R associations in the Southern Milky Way is entirely due to observational selection. The Curtis Schmidt telescope on Cerro Tololo will shortly be used for a systematic survey of southern reflection nebulae.

One of the most striking features revealed by the distribution of R associations is that the Orion spiral arm is inclined to the galactic plane. In Cygnus and Cepheus the Orion arm is located approximately 50 pc *above* the plane; the Orion arm crosses the galactic plane in Cassiopeia and remains *below* the plane from Perseus to Canis Major.

TABLE I
Data on associations of reflection nebulae

Association	l^{II}	b^{II}	$d(\text{pc})$	$z(\text{pc})$	References
Sgr R1	13	- 0.8	1200	- 17	1
Aql R1	30	+ 4	380	+ 27	4
Vul R1	67	- 1.1	2500	- 40	4
Cyg R1	77	+ 1.5	1000	+ 26	1
Cep R1	109	+ 4	650	+ 46	1
Cep R2	111	+ 12	400	+ 83	1
Cas R1	118	- 3	520	- 27	1
Cas R2	133	+ 8	310	+ 43	4
Cas R3	131	+ 1	750	+ 13	4
Cam R1	142	+ 2	870	+ 30	1
Per R1	158	- 18	330	- 100	1
Tau R1	166	- 24	110	- 45	1
Tau R2	171	- 17	135	- 39	1
Aur R1	173	- 3.5	1500	- 90	4
Tau-Ori R1	201	- 17	360	- 105	1
Mon R1	201	- 1.0	1050	- 18	1
Ori R1 + R2	208	- 17	600	- 170	1
Mon R2	216	- 12	950	- 180	2
CMa R1	224	- 2	690	- 30	1
CMa R2	236	- 14	800	- 190	3
Sco R1	354	+ 20	145	+ 50	1

1 = Racine (1968); 2 = Racine (1968) revised; 3 = Van den Bergh (1968); 4 = Racine (1970).

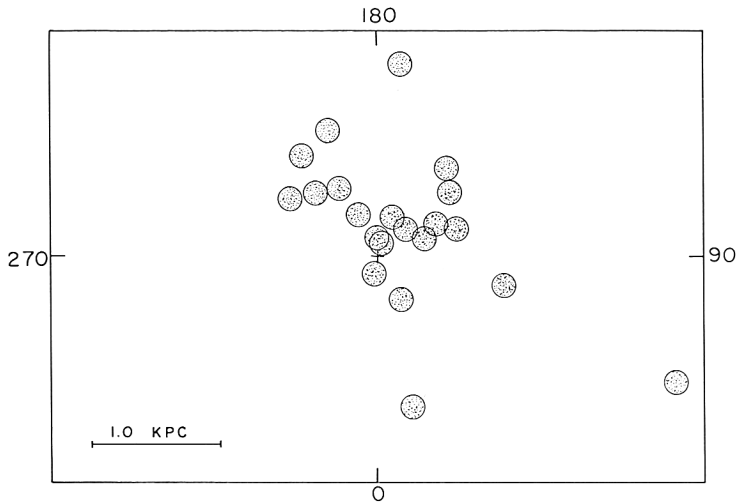


Fig. 2. Plot of the positions of R associations projected on the galactic plane. The position of the sun is marked by a cross.

The most southern R association that has so far been observed in the Orion Spiral arm is CMa R2 (Van den Bergh, 1968) which is situated 190 pc below the galactic plane. Additional southern hemisphere observations will be required to see if the Orion arm peters out at this point or whether it continues on and dips down again into the galactic plane.

References

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