

THE DWARF SPHEROIDAL COMPANIONS TO THE ANDROMEDA NEBULA

SIDNEY VAN DEN BERGH*

David Dunlap Observatory, University of Toronto, Richmond Hill, Ontario, Canada

Received 1973 December 19; revised 1974 January 18

ABSTRACT

All three of the dwarf spheroidal companions to the Andromeda Nebula have been resolved with the Hale telescope. Resolution occurs at approximately the same magnitude level as it does in NGC 185. Furthermore, a search in a 700 square degree area shows that these dwarfs are concentrated toward M31. These observations strengthen the conclusion that these objects are members of the Andromeda subgroup of the Local Group.

Subject headings: galaxies — galaxies, individual

I. OBSERVATIONS WITH THE 48-INCH SCHMIDT

Three dwarf spheroidal systems have recently been found during a survey of an area of ~ 350 square degrees centered on M31 (van den Bergh 1972a). The present paper reports an extension of this survey to a total area of ~ 700 square degrees. The survey was carried out with the Palomar 48-inch (126-cm) Schmidt telescope on 36×36 cm IIIaJ plates exposed behind a Wratten 2C filter. Exposure times ranged from 75 to 90 minutes. Plates taken in 1970 and 1971 were baked in air; those taken in 1972 and 1973 were baked in nitrogen. Since certain types of plate flaws on IIIaJ emulsion resemble the faint smudgelike images of dwarf spheroidal galaxies, it was necessary to photograph each field in the survey area twice. The coordinate boundaries of the present survey are listed in table 1 and plotted in figure 1. The 1972–1973 work extends the area searched for dwarf spheroidal galaxies to the east, south, and west. Because of galactic absorption it was not deemed worthwhile to extend the search for new companions to M31 in a northerly direction. No new dwarf spheroidal galaxies were found during the 1972–1973 search program. This result indicates that the dwarf galaxies in the survey area are concentrated toward the center of the M31 subgroup of the Local Group.

II. OBSERVATIONS WITH THE 200-INCH TELESCOPE

Additional support for the conclusion that these dwarf galaxies are physically associated with the Andromeda Nebula is provided by the observation (van den Bergh 1972b) that the object And III is resolved into stars at approximately the same magnitude level as NGC 185. Presumably $V \simeq 21.8$ for the brightest stars in And III, as it is in NGC 205 (van den Bergh and Racine 1967).

During the 1973 observing season the Hale telescope was used to obtain direct plates of all three of the new companions to M31. In all cases these systems were easily resolved on 140-min exposures on baked IIIaJ behind a GG13 filter in seeing 2–3. The magnitudes

* Based on observational material obtained as a guest observer at the Hale Observatories.

TABLE 1

AREA SEARCHED FOR DWARF GALAXIES

$26^\circ < \delta^* < 32^\circ$,	$23^h33^m < \alpha^* < 01^h45^m$
$32^\circ < \delta^* < 38^\circ$,	$23^h29^m < \alpha^* < 01^h51^m$
$38^\circ < \delta^* < 44^\circ$,	$23^h23^m < \alpha^* < 01^h56^m$
$44^\circ < \delta^* < 50^\circ$,	$23^h15^m < \alpha^* < 02^h05^m$

* Epoch 1950.

of the brightest stars were observed to be approximately the same in And I, And II, and And III. Figure 2 (plate 15) shows that And II is well resolved into a swarm of very faint stars.

Strip counts (each strip having a width of $23''.4$) in an $15'.6 \times 15'.6$ area containing the dwarf spheroidal galaxy And I are shown in figure 3. Unfortunately this area is larger than the $11'$ diameter field of good definition of the $f/3.67$ Ross corrector at the prime focus of the 200-inch. As a result the background count level is not well established. Adoption of a background of 40 counts per strip yields a total of approximately 2500 stars in And I brighter than the plate limit. A contour map of the star counts in And I is shown in

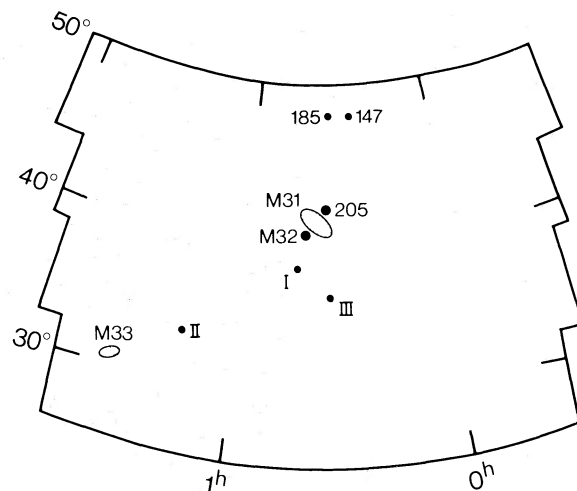


FIG. 1.—Boundaries of area searched for companions to M31.

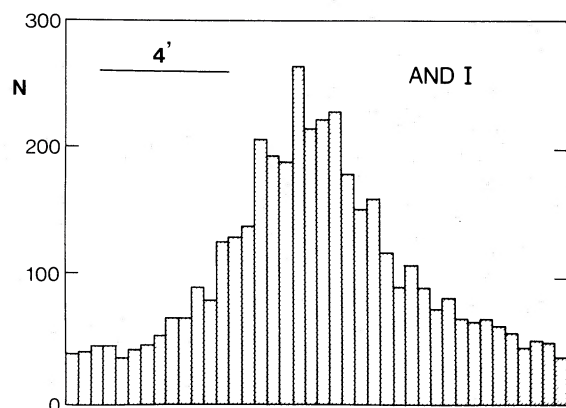


FIG. 3.—This histogram shows the results of strip counts in And I. Each strip was $23''$ wide and $936''$ long. The figure shows that And I has approximately 2500 members brighter than the plate limit.

figure 4. Even though And I was offset from the plate center, it was not possible to determine the tidal radius of And I from the present data. Such information on the tidal radii of the dwarf companions to M31 would have been of value since it might have provided some insight into the orbital characteristics of these systems. Hopefully such data will soon be obtained from star counts on plates obtained with the wide-field 4-m Mayall telescope of the Kitt Peak National Observatory.

Inspection of direct plates obtained with the Hale telescope shows no obvious globular clusters within $\sim 4'$ of the centers of the three dwarf spheroidal systems studied in this investigation. This result is not entirely unexpected because the new dwarf companions to M31 are much less luminous than the Fornax system, which is the only dwarf spheroidal that is known to contain globulars.

The almost certainly incomplete census of nearby dwarf spheroidal galaxies shows that nine out of 20 certain members of the Local Group are of this type. This observation suggests that dwarf galaxies may

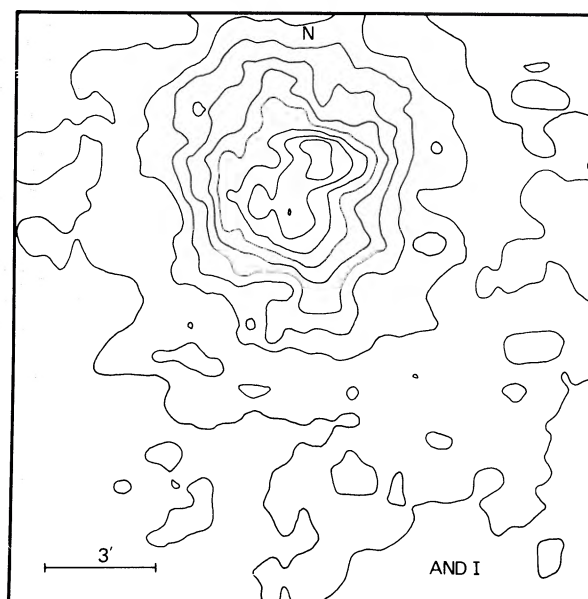


FIG. 4.—Contour map of And I constructed from counts in $70''$ squares. The contour interval is 15 counts. The map extends beyond the $11'$ diameter field of good definition of the $f/3.67$ Ross corrector. Since the luminosity function of And I is rising very steeply at the plate limit, the counts are ultra-sensitive to small localized variations in emulsion sensitivity.

outnumber all other types of galaxies in the Universe combined!

I wish to thank Steven and Annelies van Agt for the use of a computer program for plotting the equidensity contours of And I. Thanks are also due to Tricia Edwards and Betty Herbst for help with the data reduction. The kind hospitality of the Director of the Hale Observatories is gratefully acknowledged. Special thanks go to Gary Tuton and Juan Carrasco for their assistance during the observations. This work was supported by the National Research Council of Canada.

REFERENCES

- van den Bergh, S. 1972a, *Ap. J. (Letters)*, **171**, L31.
 ———. 1972b, *ibid.*, **178**, L99.
 van den Bergh, S., and Racine, R. 1967, *A.J.*, **72**, 69.

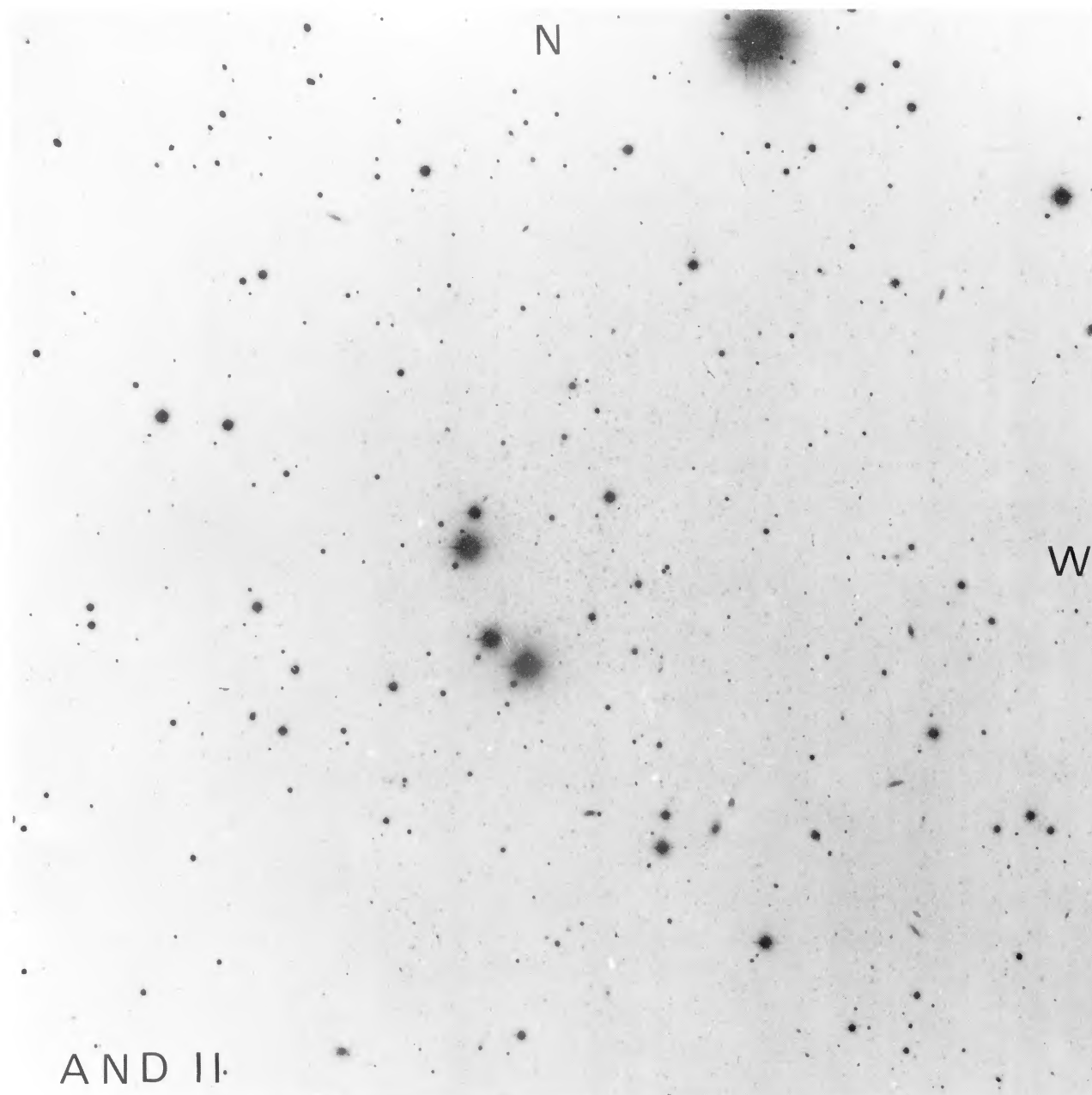


FIG. 2.—140-min exposure of And II on IIIaJ emulsion with the 200-inch Hale telescope. The area shown in this figure is 14' square.

VAN DEN BERGH (*see* page 271)