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PLANETARY NEBULAE IN LOCAL GROUP GALAXIES. I. IDENTIFICATIONS IN NGC 185, NGC 205, AND NGC 221

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ABSTRACT

We present identifications of planetary nebulae in NGC 185 (4), NGC 205 (12), and NGC 221 (10). We identified the nebulae by isolating their [O III] λ5007 and Hα emission lines. These nebulae will allow us to directly determine chemical abundances in elliptical galaxies in the Local Group.

Subject headings: galaxies, individual — planetary nebulae

I. OBJECTIVES

Three external galaxies in the Local Group contain previously identified planetary nebulae. Baade (Baade 1955; Swope 1963) identified five planetary nebulae in one field in M31, and several investigators (see Westerlund 1968) identified approximately 100 planetary nebulae in the Large and Small Magellanic Clouds. In this series of papers we present identifications of planetary nebulae in additional galaxies of the Local Group. For some of these nebulae we present determinations of chemical abundances derived from photoelectric spectrophotometry.

The direct determination of abundances for individual stars in Local Group elliptical galaxies is impossible because of the apparent faintness of even their brightest stars. Planetary nebulae in these elliptical galaxies are as bright in the stronger emission lines as the brightest giants are in the entire visual continuum. Consequently, spectrophotometry of planetary nebulae presently provides the only means of making direct abundance determinations in the Local Group elliptical galaxies. These determinations enable us to investigate the helium abundance and to study nucleosynthesis in low-mass elliptical galaxies.

In this *Letter* we identify planetary nebulae in the Local Group elliptical galaxies NGC 185, NGC 205, and NGC 221 (M32). We describe our observational techniques in § II and discuss the identifications in NGC 185 in § III, in NGC 205 in § IV, and in NGC 221 in § V. Subsequent papers will present the abundance determinations for the brighter nebulae.

II. OBSERVATIONS

Our survey for planetary nebulae utilizes a Westinghouse WL-30677 image intensifier and IIa-D plates at the f/5 prime focus of the Lick Observatory 120-inch (3-m) telescope. The image intensifier magnifies the image on the photocathode by approximately 0.64. The resulting effective focal ratio is f/3.2. We isolate Hα or the [O III] λ5007 line in the nebulae with a pair of plates taken sequentially through on-line and off-line interference filters. The central wavelengths (λ_c) and the full

widths at half-maximum transmission (FWHM) of the filter pairs are λ_c5020(50 Å FWHM)/λ_c5300(200 Å FWHM) and λ_c6573(20 Å FWHM)/λ_c6065(175 Å FWHM). The off-line filters transmit in spectral regions that are free of strong lines from the nebulae, from the night sky, and from mercury and neon in city lights. The exposures are balanced for each plate pair to give equal sky densities. To minimize the effect of spatial variation of photocathode sensitivity on images near the plate limit the exposures of an on-line/off-line pair are made with the image of the galaxy in the same position on the photocathode.

We have used primarily the [O III] filter pair due to the scant availability of 120-inch telescope time. Nebulae identified with that pair are moderate to high in excitation. We reach a plate density of approximately 0.6 for the dark sky through the λ_c5020(50 Å FWHM) filter in 30 minutes at Mount Hamilton. The shadow of a mask at the edge of the photocathode in the figures shows that the background is primarily the sky rather than image-tube dark current. Our limiting monochromatic magnitude for λ5007 emission corresponds approximately to $V = 22.5$.

III. NGC 185 (E_{pec})

We identified four planetary nebulae in NGC 185. We obtained a pair of λ5007 on-line/off-line plates on 1972 August 13 and another pair on 1972 August 14. We identified the four planetary nebulae on both pairs of plates. Figure 1 (plate L1) is a reproduction of the August 13 λ5007 on-line plate with identifications of the nebulae. NGC 185-1 appears on the 100-inch red plate on which Baade (1944) resolved NGC 185 into stars. Spectral scans of NGC 185-1 show that it is an intermediate-excitation nebula with a ratio (λ5007 + λ4959)/Hβ of 16.

Since NGC 185 is approximately 7° north of M31, there is no likelihood that the nebulae in figure 1 are H II regions or planetary nebulae projected from M31. NGC 185 is a peculiar elliptical galaxy because it has absorption patches (Baade 1944; Hodge 1963) and approximately a dozen blue stars (Baade 1951; Hodge 1963). Hodge's absorption regions I and II appear in figure 1. NGC 185-3 projects onto absorption region II. The other three nebulae show no apparent tendency to associate with the dust.

We obtained a pair of λ5007 on-line/off-line exposures of NGC 147, the elliptical companion to NGC 185, on 1972 August 14 during poor seeing. We did not identify any nebulae on the plates.

IV. NGC 205 ($E_{pec}/S0_1$)

We identified 12 stellar nebulae in NGC 205. We obtained a pair of λ5007 on-line/off-line plates on 1972 July 14. Figure 2 (plate L2) is a reproduction of the λ5007 on-line plate with identifications of the nebulae. Numbers 11 and 12 are near the plate limit and are questionable identifications. All the nebulae are within the boundary of the galaxy as seen on the *Palomar Observatory–National Geographic Society Sky Survey* red print. Spectral scans of NGC 205-1 and NGC 205-8 yield ratios (λ5007 + λ4959)/Hβ of 5 and 14, respectively.

Because NGC 205 is near M31, we must consider the possibility that H II regions and planetary nebulae project from M31. The five planetary nebulae that Baade identified (Swope 1963) occur in field IV, 96′ southwest of the center of M31 along the major axis. The position of NGC 205 projected onto the disk of M31 is farther from the center of M31 than field IV. Since the area of our photocathode is five times smaller than the area of field IV, NGC 205 should be contaminated negligibly by nebulae projected from M31. Inspection of the *Sky Survey* prints and Arp's (1964) Hα interference-filter photograph of M31 and its companions reveals that no faint outer spiral arms of M31 project onto NGC 205. These arguments and the further

PLATE L1

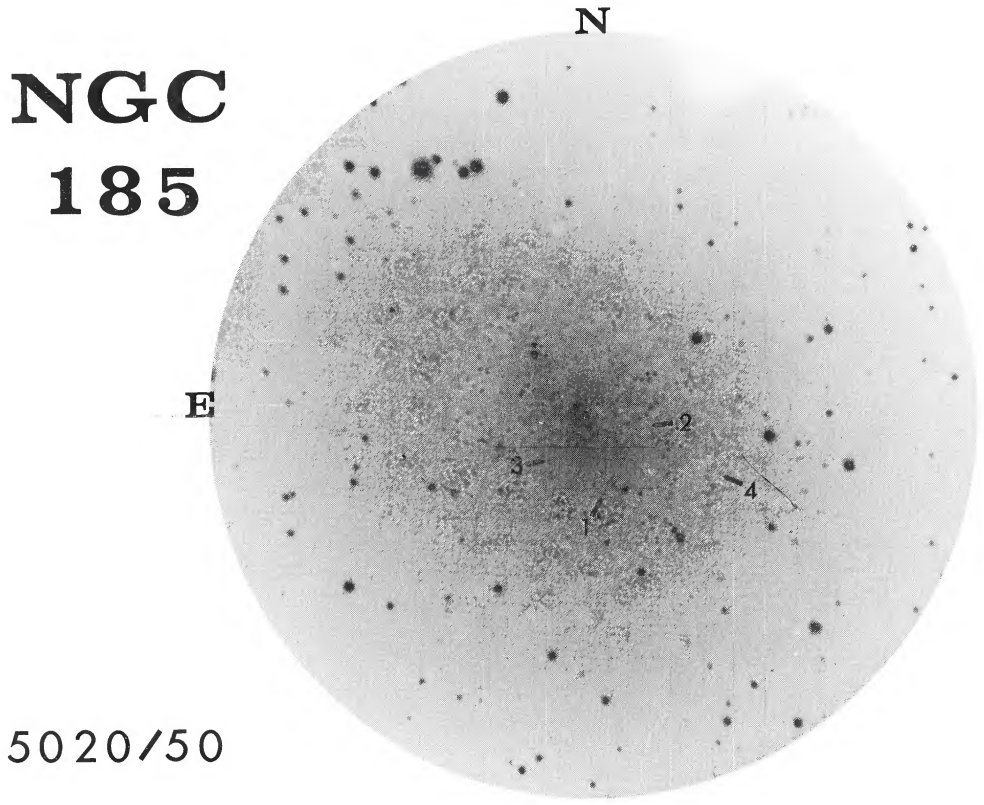

FIG. 1.—Identifications of four planetary nebulae in NGC 185. The plate isolates [O III] λ5007 with the interference filter λ_c5020 (50 Å FWHM). The field is 9′ in diameter.

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PLATE L2

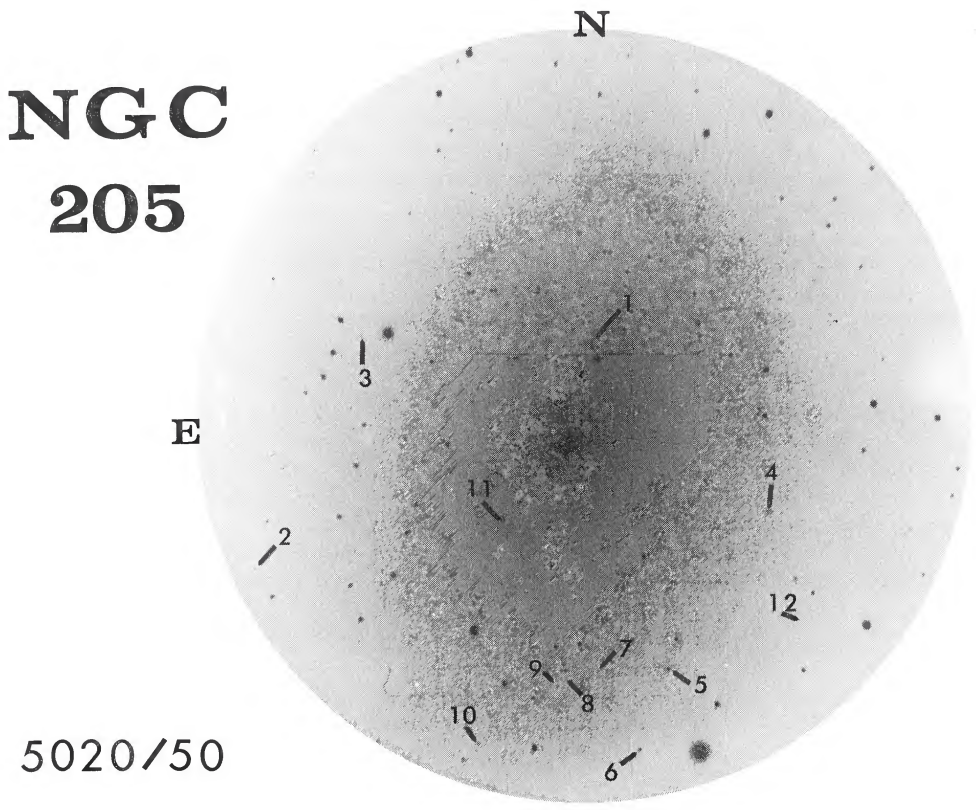

FIG. 2.—Identifications of 12 planetary nebulae in NGC 205. See fig. 1 legend for details.

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observation that the nebulae are stellar and show no continuum on the off-line plate lead us to conclude that the nebulae are planetary nebulae and that they are members of NGC 205.

NGC 205 is a peculiar elliptical galaxy because it has absorption patches and blue stars that are strongly concentrated to its center (Baade 1951; Hodge 1973). The planetary nebulae show no tendency to associate with the absorption patches or with the blue stars. We have no explanation for the apparent clumping of the nebulae in the southern end of the galaxy.

V. NGC 221 (E2)

We identified 10 stellar nebulae and two diffuse nebulae in NGC 221 (M32). We obtained a pair of λ5007 on-line/off-line plates on 1972 July 14 and a pair of Hα on-line/off-line plates on 1972 July 13. Figure 3 (plate L3) shows a reproduction of the λ5007 pair of plates with nine stellar and two diffuse nebulae identified on the on-line photograph. Five of the stellar nebulae also appear on the Hα on-line plate. An additional nebula, NGC 221-10, appears only on the Hα plate where it is the brightest nebula; the approximate position of this low-excitation nebula is indicated in figure 3. A spectral scan of NGC 221-1 shows it to be an intermediate-excitation planetary nebula with a ratio (λ5007 + λ4959)/Hβ of 12.

Baade and Arp (1964) identified and catalogued 688 emission nebulae in M31. None of those H II regions project onto the area shown in figure 3. Inspection of the *Sky Survey* prints and the spiral structure of M31 derived from the H II regions by Baade and Arp and by Arp (1964) indicates that a spiral arm does project across the northeastern half of NGC 221. The two diffuse nebulae seen in emission on both sets of plate pairs also show weak continua on the off-line plates. We presume that the diffuse nebulae are H II regions from the spiral arm projected onto the field.

We now note that: (1) four planetary nebulae appear in NGC 185, where there is no question of H II regions or planetary nebulae projected from M31; (2) 10 certain planetary nebulae appear in NGC 205, which should be contaminated negligibly by projected nebulae from M31; (3) the stellar nebulae in NGC 221 are concentrated to the center of the galaxy—seven of the 10 are within a radius of one-quarter of the field diameter centered on NGC 221, an area where they are the most difficult to detect due to the surface brightness of NGC 221. These three points lead us to conclude that the stellar nebulae are planetary nebulae and that the majority of the 10 are members of NGC 221.

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NGC 221

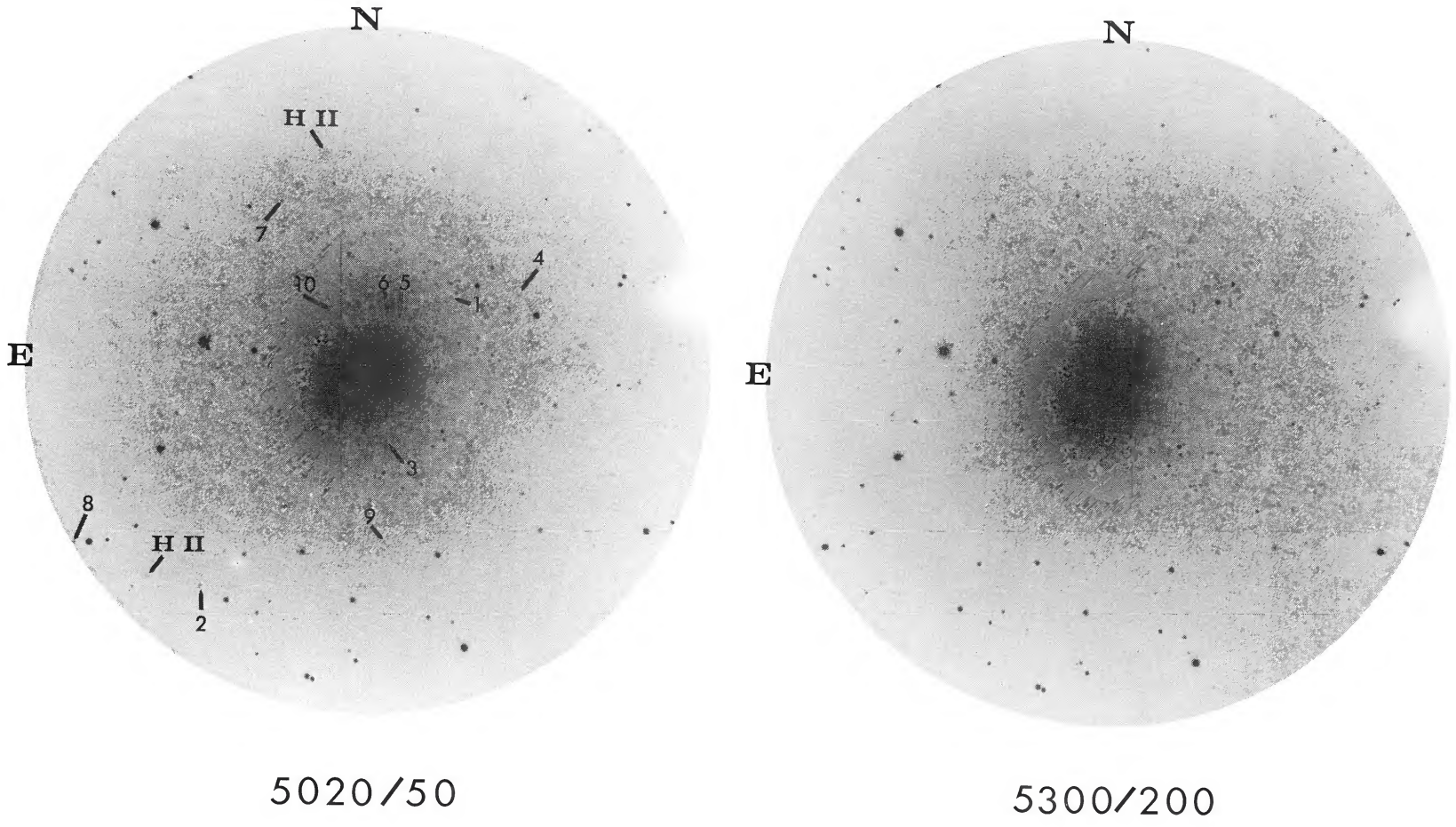

FIG. 3.—Identifications of 10 planetary nebulae and two H II regions in NGC 221 (M32). The left plate isolates [O III] λ5007 with the interference filter λ_c5020 (50 Å FWHM), and the right plate excludes λ5007 with the interference filter λ_c5300 (200 Å FWHM). The indicated position of nebula number 10 is approximate. It appeared only on an Hα plate, where it was the brightest nebula.

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