THE OPTICAL WARP OF NGC 5907

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Abstract. A study was made of the optical warps of NGC 5907, by means of CCD photometry, for the U and I filters, as well as for a narrow band filter centred at Hα. Our observations were extended out to about 380 arc sec in the NW side and out to about 348 arc sec in the SE side. The HI warps begin at these galactocentric radii, so that the optical ones are not clearly distinguished. The U warp is larger than the I one in the NW, but this difference is not appreciated in the SE. The disk shows slight corrugations.

1. Introduction

The warps of NGC 5907 have been subject to two important studies. Sancisi (1976) published his 21 cm map rendering this galaxy as a prototype of a warped disk galaxy, which most theoretical models try to fit, and Sasaki (1987) made a detailed photographic photometric study. This galaxy was also detected by van der Kruit (1979) and van der Kruit and Searle (1982). The aim of this paper is to contribute with CCD photometry to the observational description of these warps.

There is also an important question, related to the physical interpretation of these phenomena that previous observations of NGC 5907 have left unclear. Battaner et al. (1990) predicted that the warp's curve would be different when observed with different wavelengths, being '21 cm-blue-red' the sequence ordered from higher to lower distortion. Florido et al. (1991a) found that blue warps were indeed more developed than the red ones, by means of CCD photometry, in NGC 4013, NGC 4565, and NGC 6504. Sasaki (1987) found a gas warp larger than the optical warp, but he interpreted this fact not as a real morphological characteristic, but rather as an apparent effect caused by internal absorption and sudden truncation of the stellar disk. As absorption is larger for blue wavelengths, if this interpretation were correct, and if the stellar and gaseous disks were warped to the same degree, then a sequence '21 cm-red-blue' should be observed. Unfortunately, Sasaki made the observations for two colours, but in the paper, only plotted the position for one of them. Thus the question to be solved, of great theoretical interest, is therefore, in NGC 5907, which is larger, the blue or the red warp?

Apart from the galaxies studied by Florido et al. (1991a) not many observations about this problem have been published, with the exception of our own Galaxy. Here, the warp is well observed in HI (Kerr, 1957, 1982; Kulkarni et al., 1982; and others), in H II-regions (Fick and Blitz, 1982), in γ-rays (Mayer-Hasselwander et al., 1982; Phillips...
et al., 1981), in dust (Burns et al., 1984), and, therefore, it should be present for young stars. However, it was never found for early-type stars. Ichikawa and Sasaki (1984) reported negative results for M-giants, and so did McNeil (1986) for G5–M giants. The same negative result in a search for early-type star warps was also noted by Guibert et al. (1978). A near-infrared survey of the galactic plane would elucidate this question.

Let us advance that in the case of NGC 5907, our observations did not give a clear answer to this question. At least, in this respect, NGC 5907 was not a prototype galaxy.

2. Observations

Observations were made with the 2.5 m INT located in Roque de los Muchachos (La Palma, Spain), using a GEC–CCD detector, and obtaining 0.54 arc sec per pixel. The images were biased and flat-field corrected and the sky background, field stars and cosmic rays were removed from them. Calibration was made with the standard stars G163250 and 104Z337 and the atmospheric extinction was reduced by standard methods. Some details of the reduction procedures are described in Florido et al. (1991a, b) as well as the way in which the centroid's curves representing the warp were obtained.

Figures 1(a–f) show the isophote maps for the NW and the SE for three different filters: U, I, and a narrow-band filter centred in Hα. Figure 2 shows another image for the Hα filter, slightly rotated to obtain a larger image of the south side of the galaxy. A first consideration of these images indicates that the warps are still not clearly developed at these galactocentric radii. On the north-west side the warp seems to have the same direction as the H I warp, it is not clearly observed in Hα and it has the opposite direction in the I filter. On the south-east side the warp seems to have the H I warp direction for the three filters.

Figures 3(a) and 3(b) show the warp curves obtained as in Florido et al. (1991a, b), reinforcing the direct impression. However, as just the beginning of the warps is observable and the obtained points are very noisy we have also plotted the first derivative (slope versus radius) calculated with 100 points (pixels) with steps of 10 points. The change in slope is more pronounced on the south–east side for the U filter. In the north the U slope curve is also more pronounced than the I slope curve. The results are plotted in Figures 4(a) and 4(b). This kind of plot is interesting to detect warps, as the position angle cannot be determined with a high precision and, therefore, the z-values may have a serious error. The slope curves support the larger U warp.

Some of the profiles seem to show corrugations, such as those found in our own Galaxy (Quiroga, 1977; Spicker and Feitzinger, 1986; and others) with a direct influence in the solar neighbourhood (Alfaro et al., 1991), and in other galaxies (Florido et al., 1991b). These authors have determined typical wavelengths of the corrugations of about 2–3 kpc. Our correlation analysis (Figure 5) for the northern side of NGC 5907 indicates no clear wavelength for the I and Hα-filters; the U filter shows a typical length of about 89 arc sec, which is equivalent to 4.7 kpc, larger than in other galaxies. On the southern side no corrugation was detected.