CHALLENGES OF USING PLANETARY NEBULAE FOR EXTRAGALACTIC DISTANCES

L.BOTTINELLI[1,2], L.GOUGUENHEIM[1,2], G.PATUREL[3], P.TEERIKORPI[4]
[1]Observatoire de Paris, Section de Meudon, Arpèges/CNRS URA 1757, F-92195 Meudon Cedex, France
[2]Université Paris XI, F-91405 Orsay Cedex, France
[3]Observatoire de Lyon, F-69561 Saint-Genis Laval Cedex, France
[4]Tuorla Observatory, University of Turku, SF-21500 Piikkiö, Finland

1. Introduction

The planetary nebulae (hereafter PN) distance criterion (Ciardullo et al. 1989a) relies on the shape adopted for the luminosity function (hereafter LF) and its adequate fit to the observed data. Crucial hypothesis concerning the LF are its universal shape with an universal value of the absolute magnitude cut-off and concerning the sample, its completeness and the selection of the rejected data.

Because the completeness is achieved only in the bright part of the LF, the brighest PN play a crucial role in the distance determination and it is well known that the brightest objects (with intrinsic scatter) in a giant galaxy are brighter than in a dwarf galaxy. Thus more luminous galaxies are given smaller distances. Because giant galaxies are rare they are not seen at small distances; on the contrary, they are typically observed at large distances. This effect induces a progressive compression of the distance scale.

2. Direct observational evidence

Bottinelli et al.(1991) have put in evidence this trend in the Virgo cluster where the brighest galaxies only had their distances determined from PN (Jacoby et al. 1990). As expected the more luminous galaxies are derived smaller distances. The reality of this trend has been criticized. The main points were : (1) the surveyed magnitude is a better indicator of the sample size than the total galaxy magnitude. But the same trend is still present when using this surveyed magnitude; (2) apparent magnitudes are not good indicators of absolute ones, because of the depth of the cluster. This raises the question of

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whether the PN method is able to evidence this depth, that is far from being settled.

Another evidence of the sample size effect is given by Tammann (1993). He shows that the size of the surveyed region increases with increasing distance by a factor of 7 from M31 to Virgo and that the mean luminosity of the 3 brightest PN increases when this population size increases.

3. The exponential shape of the bright end of the PNLF

When applying the maximum likehood method to an exponential PNLF, the total population and the distance modulus μ are not derived separately. Thus, if the population of the calibrating galaxy and of the observed galaxy are different, this population effect leads to determine μ' instead of μ and the difference (μ'-μ) is expected to decrease with increasing luminosity which is truly observed. Moreover the slope 1.6 predicted for the bright end of the PNLF is in good agreement with the data. Another prediction concerns the specific PN density $\alpha_{2.5}$ as derived by Ciardullo et al.(1989b) and Jacoby et al.(1990a). While $\alpha_{2.5}$ is assumed to be a constant, it varies strongly from galaxy to galaxy depending on the luminosity of the surveyed population. The observed dependence is quite explained as a consequence of the exponential bright end of the PNLF and cannot result from the kind of colour effect discussed by Peimbert (1990) because the galaxies here involved cover a narrow range of colours.

4. Completeness of PN's sample

The shape of the observed LF depends strongly on the selection of the data. For example, 11 very bright PN have been discarded in Virgo as being said to be overluminous. However the probability to get brighter PNs increases with the size of the sample which is large in this case. There is no really convincing reason to ignore these bright PNs that influences strongly the shape of the bright end of the LF which is now strongly dependent of a single selected bright PN. The derivation of the PN magnitude completeness limit relies on the assumption of a constant specific PN density within the galaxy; however a radial gradient is observed in NGC 5128 (Hui et al., 1993) and this makes the method questionable. The reliability of detectability is also a difficult problem as illustrated in the case of Leo group galaxies; Wagner and Tammann (1994, this JD, poster session) do not recover all the PN listed by Ciardullo et al. (1989b) and find on the contrary a large number of additional PN. The homogeneity of the detection rate is important in the constitution of the statistical sample and some regions of incompleteness are identified and excluded within a galaxy. For example, in the case of NGC1404 in Fornax (Mac Millan et al., 1993) only 14 PNs among the 20 brighter than the completeness limit should have been taken and doing this a distance modulus larger by about 0.2 mag. should have been derived.

5. Conclusion

The PN distance determination relies on the use of an **universal** luminosity function fitting some **selected** data. One crucial point relies on this selection and statistical tests qualifying how these selected data fit the theoretical curve tell nothing about the selection itself. Observational evidence for the constancy of the magnitude cut-off is needed.

The PN method does not seem to be yet fully stabilized. One example is the specific PN density which was first taken as being universal, a property used to ascertain of the completeness of the sample.

There are observational evidences for PN distance determination to be sensitive to **population size** which leads to a **compressed** distance scale. Confirming this bias needs a precise and independent distance criterion. Observations of cepheid variable stars in Virgo cluster spirals will undoubtly bring this criterion. However, the determination of the Virgo cluster distance itself and that of suspected subclusters within, will need cepheid stars to be observed in a sufficient number of Virgo galaxies. It might be expected then that these good distance determinations will bring in return more informations on the PNLF itself.

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