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Spatial Structure of NGC 6822: An Example for Statistical Modeling of Astronomical Data

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Abstract. The spatial distribution of stars in the Local Group dwarf irregular galaxy NGC 6822 has been studied, using recent positions and deep photometry for about 15,000 stars in the galaxy. Based on photometrical data, OB stars and red stars could be studied separately. Spatial statistical tools have been applied to the analysis of the spatial structure. The primary aim of the analysis was to find associations among OB stars of the sample in statistical way; that is to quantify the grouping tendency visible in the images of the dwarf galaxy with the aid of merely statistical models. In the present paper the technical aspects of the analysis are discussed.

1. Introduction

The Local Group dwarf irregular galaxy NGC 6822 is characterized by small dimensions and structural simplicity; its distance is about 500 kpc. The surface distribution of stars in the direction of NGC 6822 (total: 22,958 objects) came from recent position and deep photometric observations (Gallart et al. 1994 and references therein). After removing the foreground contamination (estimated by the aid of a representative comparison field located near to the galaxy) 15,343 objects retained in the sample.

Blue stars [$(B-V)<0.5$ and $(V-R)<0.35$; a total of 1,631 objects] and red stars [$(V-R)>0.65$; a total of 8,998 objects] in the filtered sample were separated in $(B-V)-(V-R)$ parameter space which was accompanied by a separation also in $2D$ geometrical space (a similar effect was published for NGC 3109 by Bresolin et al. 1993).

Our approach to group identification has been based on merely statistical tools, as opposed to recent works on similar efforts finding associations in nearby galaxies, like Bresolin et al. (1993 or Wilson (1991, 1992). The main characteristic of the present method is the subsequent refinement of point process models fitted to the sample.

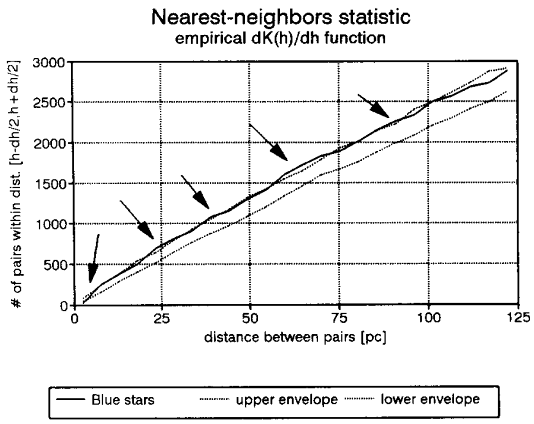

Figure 1. Identification of significant scales by NNS.

2. Model Fitting, Step 1

Rejection of CSR, (complete spatial randomness; for details on the following spatial statistical models see Pásztor and Tóth 1995) was based on the results of the NNS (nearest-neighbors statistic). Principles of NNS can be summarized as follows. Consider every pair of objects whose separation is less than a predefined limit: The number of pairs whose distance is between $h - dh/2$ and $h + dh/2$ versus their separation is a well defined function, and widely used in point pattern analysis. This function is the derivative of another important point process function, the K function which is related to second-order properties of point processes (for details see Cressie 1991). For HPP (homogeneous Poisson point process), the function is linear: upward deviation indicates aggregation, while a deviation downward is due to some regularity in the point pattern. The significance of deviation from CSR results from comparisons to 100 Monte Carlo simulations of HPP, so the significance of deviation from CSR is $p < 0.01$ for every scale.

3. Model Fitting, Step 2

Refinement of the model was carried out by taking into consideration the apparent large-scale structure present in the sample. The newer 100 Monte Carlo simulations were generated as realizations of IPP (inhomogeneous Poisson point process) with fixed (and identical with that of the real sample) marginal distributions (Pásztor et al. 1993). Result of NNS (Figure.1) shows significant ($p < 0.01$) clustering at around the scales of 25, 40, 65, and 90 pc, and additionally vacancies at scales smaller than 5 pc. This latter is a resukt of an SIP (simple inhibition point process), and is probably due to the limit in resolution of the observations.

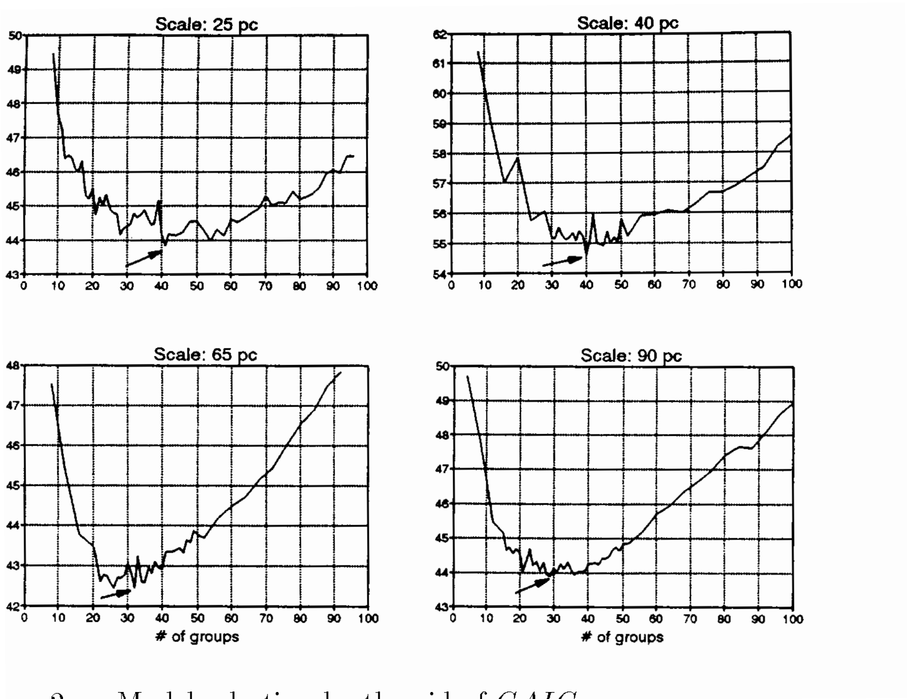

Figure 2. Model selection by the aid of $CAIC$.

4. Model Fitting, Step 3

All of the objects which dominant the significant clustering at a given scale are thought to be members of groups with a characteristic size comparable with the scale value. However the number, shape, and location of these groups is *a priori* unknown. A sequence of non-hierarchical clustering models was carried out, providing partitions of the sample as well as results of PCP (Poisson cluster process) models. In choosing an optimum and minimal model over the set of these competing models, an information theoretic criterion, the $CAIC$ (a more strictly inforced version of Akaike's Information Criterion) (Eisenblätter and Bozdogan 1988), was used (Figure 2).

5. Results

A final partition of the blue stars into groups (associations) on the level characterized by characteristics scale of 25, 40, 65, and 90 pc can be seen on Figure 3. Circles with radii of the scale values should not be interpreted as anything but models of fuzzy sets with radii varying around these values. Th centers scattered around the centers of the resultant circles, and shapes are approximate.

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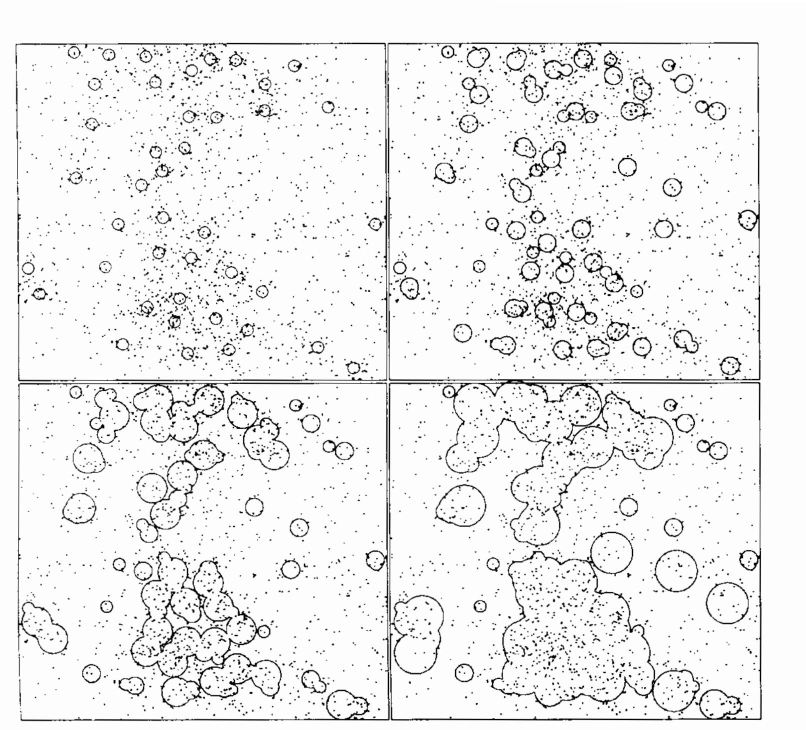

Figure 3. Clustering of OB stars on scales of 25, 40, 65 and 90 pc.

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