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# IR STAR FORMING KNOTS IN GRAND DESIGN SPIRAL GALAXIES: SPIRAL STRUCTURE STAR FORMATION CONNECTION

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RESUMEN

Estamos estudiando una muestra de 46 galaxias Grand Design de una gran variedad de tipos morfológicos, que fueron fotografiadas en la banda K con el telescopio NTT del ESO, Chile. Once galaxias muestran fuerte correlación entre la distribución de las condensaciones y la componente de Fourier m = 2 de su estructura de brazos. Para cinco galaxias derivamos la resonancia de corrotación (CR) del patrón espiral de dos brazos

ABSTRACT

We are studying 46 Grand Design spirals widely spread in types, which have been imaged in the K-band with the ESO NTT telescope. Eleven objects show knots strongly associated to the m = 2 Fourier component of the spiral structure. Corotation ressonance (CR) for the two-armed pattern have been derived for five galaxies.

*Key Words:* galaxies: spirals — H II regions — ISM: dust, extinction — stars: early-type



## 1. INTRODUCTION

Grand Design spiral galaxies often display strings of bright knots along their arms on deep, near-infrared K-band images. These knots are frequently strongly embedded in dust lanes and barely observed in optical bands. These circumstances suggesting that they are young stellar clusters just being formed (Grosbøl & Patsis 1998). J- and K-band spectroscopy allowed to detect Hydrogen Br$\gamma$ in emission in eight knots of NGC 2997 (Grosbøl et al. 2006), indicating that the knots are dust enshrouded HII regions. Furthermore, knots K-band flux comes from continuum radiation (Patsis et al. 2001). We then decided to statistically study NIR bright knots associated to spiral structure of 48 Grand Design spiral galaxies. The rate of star formation (SFR) in NIR derived from K-band fluxes through Starburst99 (Leitherer et al. 1999) may complement or correct SINGG SFR obtained from H$\alpha$ in emission.(Meurer et al. 2006; Hanish et al. 2006). Indeed, due to dust absorption few of the NIR knots would hardly contribute to H$\alpha$ Hydrogen emission line used by SINGG to estimate the star formation rate in their sample of galaxies. The corotation ressonance is an important parameter connecting the perturbation, disk kinematics to the characteristic of the mass distribution inside the disk. Eleven of the galaxies present a strong association of knots distribution with arm m = 2 Fourier component. We argue that the difference in pitch angle between the line of knots and the ridge of the m = 2 arm is due to the difference in phase between the perturbation and the socked material. That allows to detect the presence of CR ressonances (Grosbøl et al. 2006). We applied this criterium to derive CR ressonances for five of the objects.

## 2. OBSERVATIONS AND METHODS

Observations were made with SOFI at the NTT telescope at ESO, La Silla. Details on the sample, templates, calibration, etc., are presented at Grosbøl et al. (2004). The separation (Grosbøl & Dottori 2008) of the star forming knots from other sources were made by means of SExtractor program (Bertin & Arnouts 1996). Specific JAVA resources allow to estimate the degree of contamination by Milky Way stars (Robin et al. 2003) and background galaxies (Ellis & Bland-Hawthorn 2007). The MW contamination is specific to each galaxy. Background elliptical galaxies brighter that 19 mg are 6 or less for a typical frame area. SExtractor separate the objects according to their *stellar class (sc)*. Objects for which $sc = 1$ are certainly stars. We selected as candidates to star forming knots objects with $sc \leq 0.2$, that appears to be more strongly concetrated along the arms. Many of the objects with $0.2 \leq sc \leq 0.8$ might also be star forming objects, as will be discussed latter.

## 3. RESULTS AND CONCLUSIONS

In the Figure 1 we show for NGC 1187 the type of graphics we generated.

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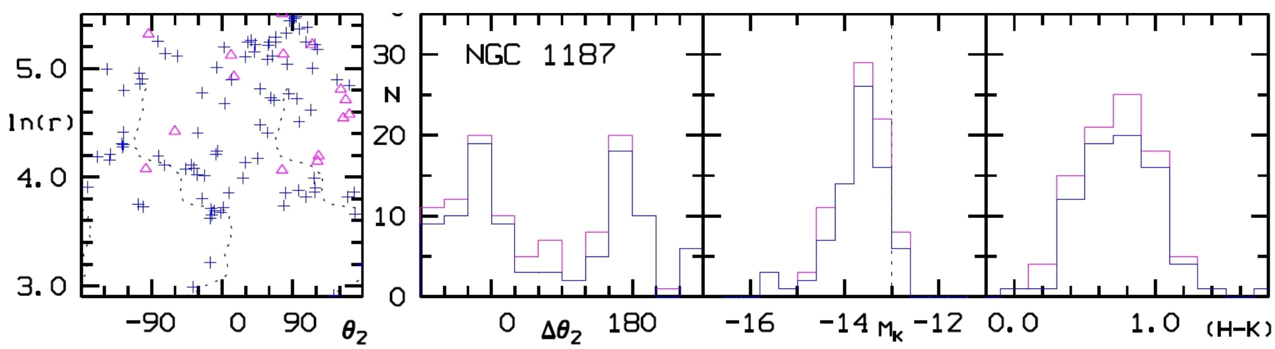


Fig. 1. From left to right we show: ln(r) vs $\theta$ of NIR emitting knots. The histogram of angular distance between knots and arms m=2 Fourier component. The distribution in $M_K$ and the distribution in $(H - K)$ color. In the last three graphics, dark-gray histogram indicates the distribution of objects with $sc \leq 0.2$.

In the ln(r) vs $\theta$ plane we show the distribution of selected emitting knots with respect to the ridge of the arms m=2 Fourier component (dashed line). With + we dettached the more likely star forming objects ($sc \leq 0.2$). We also show with triangles objects with $0.2 \leq sc \leq 0.8$. The ln(r) vs. $\Delta(\theta)$ indicates the departure between the knots and the ridge of the m=2 Fourier component. N vs $M_K$ shows the distribution of absolute K brightness, the dotted line indicates the instrumental limits. N vs. (H-K) shows the distribution in colors. 25% of the sample shows a strong concentration of young stellar knots along the m=2 arm. For the four galaxies with (H-K) vs. (J-H), Starburst99 models indicate the presence of a strong absorption (more than 4mg in the visual), even for the oldest knots.

For NGC 5247 the knots distribution follows well a logarithmic spiral between 44″ and 140″. Moreover, it shows a different pitch angle than the ridge of the m = 2 arm Fourier component. Both patterns intersect at r = 73″ probably indicating the place of the m = 2 CR ressonance. Other galaxies show also this property. For example: NGC 157, at r = 66″, NGC 3627, at r = 61″, NGC 2997, at r = 99″. The case of NGC 1566, is more duvious, since it shows two possible patterns intersections at r = 60″ and r = 168″.

K-band images of spiral galaxies provide an almost clear view of their young stellar clusters which in visual bands are obscured by dust absorption in spiral arms. K-band allows and unbiased study of the distribution of such young clusters, which probably complement the rate of star formation derived from optical bands observations.

## REFERENCES

Bertin, E., & Arnouts, S. 1996, A&AS, 117, 393
Ellis, S. C., & Bland-Hawthorn, J. 2007, MNRAS, 377, 815
Grosbøl, P., & Dottori, H. 2008, A&A, 490, 87
Grosbøl, P., Dottori, H., & Gredel, R. 2006, A&A, 336, 840
Grosbøl, P., & Patsis, P. A. 1998, A&A, 336, 840
Grosbøl, P., Patsis, P. A., & Pompei, E. 2004, A&A, 423, 849
Hanish, D. J., et al. 2006, ApJ, 649, 150
Leitherer, C., et al. 1999, ApJS, 123, 3
Meurer, G. R., et al. 2006, ApJ, 165, 307
Patsis, P. A., Héraudeau, P., & Grosbøl, P. 2001, A&A, 370, 875
Robin, A., Reylé, C., Derrière, S., & Picaud, S. 2003, A&A, 409, 523