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H I IN STARBURST GALAXIES

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RESUMEN

Se requieren grandes cantidades de gas frío para la actividad de 'starburst' en la región nuclear de las galaxias. Mientras fluya suficiente gas hacia la región nuclear, se puede mantener la actividad. Esta actividad es muy probablemente provocada por el transporte de masa hacia el centro debido a una barra. La corriente de gas a lo largo de la barra es visible en el campo de velocidades del H I. Las interacciones entre galaxias también tienen una gran importancia porque provocan la formación de barras o, en caso de interacciones fuertes o mergers, mueven directamente el gas hacia el centro. Frecuentemente se observan barras e indicios de interacciones con galaxias cercanas en galaxias 'starburst' (por ejemplo, en el Quarteto de Grus). Para entender la evolución de estas galaxias necesitamos estudiar su dinámica y su medio ambiente.

ABSTRACT

Large amounts of cold gas are a necessary ingredient for nuclear starburst activity to happen in galaxies. As long as sufficient gas is supplied to the nuclear region the starburst activity continues. One possible mechanism to trigger and fuel the nuclear activity of spiral galaxies is through the transport of gas from the disk into the center as induced by the potential of a bar. Such bar-induced streaming motions are visible in the H I velocity field. Galaxy interactions also play an important role as they can trigger the formation of bars or in case of strong interactions or mergers directly drive gas into the center. Bars as well as signs of interactions with a companion are often observed in starburst galaxies (see e.g., the Grus-Quartet). Thus, to understand the evolution of these most exciting galaxies we need to study their gas dynamics and their nearby environment.

Key words: **GALAXIES: INDIVIDUAL: GRUS-QUARTET, NGC 253, CIRCINUS, DORADO GROUP — GALAXIES: ISM — RADIO LINES: GALAXIES**

1. INTRODUCTION

Why is the study of neutral atomic hydrogen gas (H I) in starburst galaxies important?

- **In general**, the H I emission line is still the best tracer for the overall gas distribution and kinematics in galaxies. The H I envelope of spiral galaxies usually extends much further out than the optical emission, thus providing a unique means of determining the mass distribution in their outer regions.
- **In interacting galaxies** the H I line is the best tracer for tidal tails, bridges between galaxies, and low-surface brightness companions.
- **In barred galaxies** (type SB and SX) we can, e.g., use high-resolution H I velocity fields to study the gas flow in and around the bar. The galaxy velocity field directly reflects the galaxy potential.
- And **in starburst galaxies**, which are often found to be **barred and interacting** with neighbouring galaxies, we can study both phenomena by using the H I emission line. We may thus find out which mechanisms triggered and sustained the starburst activity. In addition, we can use the H I absorption against the bright and often extended nuclear continuum source to study the nuclear gas kinematics and therefore the central mass concentration. The latter technique requires the largest configurations of the existing synthesis telescopes and VLBI for distant ultraluminous galaxies.

I have recently written a comprehensive review about the relation of the large-scale gas dynamics, nuclear kinematics and activity in spiral galaxies (Koribalski 1996). Some examples are given below.

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2. OBSERVATIONS AND RESULTS

2.1. The Grus-Quartet

The Grus-Quartet consists of four large spiral galaxies: NGC 7590, NGC 7599, NGC 7582, NGC 755[cut off] Two of the galaxies, NGC 7582 and NGC 7552, are well-known starburst galaxies. Both of them are classifie[cut off] as barred. H I observations with various configurations of the Australia Telescope Compact Array (ATCA) reveal the following

- clear signs of tidal interactions, e.g., a bridge between NGC 7590 and NGC 7582 as well as an extensio[cut off] from NGC 7582 toward NGC 7552,
- an S-shaped velocity field in the nearly face-on galaxy NGC 7552 showing the bar, and
- fast-rotating nuclear rings in both NGC 7582 and NGC 7552 as indicated by high-resolution H I absorptio[cut off] measurements. A nuclear disk (diameter ~1 kpc) of H II regions and outflow of ionized gas has bee[cut off] suggested by Morris et al. (1985).

My collaborators in the study of the Grus-Quartet and the Dorado group (see below) are Tracy E. Lavezzi an[cut off] John M. Dickey from the University of Minnesota (USA) and John Whiteoak (ATNF, Australia).

2.2. The Starburst Galaxy NGC 253

One of the closest and most active galaxies in the southern sky is the well-known starburst galaxy NGC 25[cut off] a member of the Sculptor group. ATCA H I observations by Koribalski, Whiteoak, & Houghton (1995) sho[cut off] the following

- a gas envelope only slightly larger than the optical B_{25} emission,
- a rather regular velocity field, and
- a fast-rotating nuclear ring. There are also indications of a nuclear outflow.

A comprehensive study of the molecular gas distribution in NGC 253 can be found in Mauersberger et al. (199[cut off] and Houghton et al. (1996). The kinematics of the ionized gas have recently been discussed by Arnaboldi et a[cut off] (1995).

2.3. The Circinus Galaxy

Maybe less known but at least as exciting as NGC 253 is the Circinus galaxy. It is a nearby spiral galax[cut off] only 4° below the Galactic plane. The nuclear activity is caused by star formation and a prominent Seyfert nucleus. Giant radio lobes (perhaps associated with outflow) are emerging from the nuclear region (Elmoutti et al. 1995) very similar to those in NGC 3079. Freeman et al. (1977) measured a half-width of at least $32' \times 1$[cut off] for the H I extent of Circinus, much larger than the optical diameter ($\sim 10'$) of the galaxy. Jones et al. (1996[cut off] and Koribalski & Whiteoak (1996) have recently mapped Circinus with several configurations of the ATCA[cut off] The measured H I distribution shows

- several spiral arms extending over an area of at least 30′,
- an elongated central disk (length about 5′) plus a peculiar velocity field indicating a bar, and
- a central 'hole' caused by H I absorption against the bright central continuum source revealing a fas[cut off] rotating nuclear ring.

The nature of the ring and indications of a nuclear outflow of ionized gas (Marconi et al. 1994) are currentl[cut off] being studied using TAURUS Fabry-Perot Hα data taken with the 4-m Anglo-Australian Telescope (AAT).

[2]The Australia Telescope Compact Array is part of the Australia Telescope National Facility (ATNF), a division of th[cut off] Commonwealth Scientific and Industrial Research Organization (CSIRO). — For further information see our *WWW* pages a[cut off] http://www.atnf.csiro.au.

2.4. The Dorado Group

The Dorado group consists of two big spiral galaxies, NGC 6215 and NGC 6221, and several newly detected low-surface brightness galaxies. The most prominent member of the group is the barred starburst galaxy NGC 6221. ATCA observations revealed an H I bridge between NGC 6221 and NGC 6215. In addition, NGC 6221 shows several peculiar H I extensions, some of them with rather high velocity dispersion and a rather distorted H I velocity field.

3. SUMMARY

Although H I observations cannot shed much light on the starburst activity in galaxies itself, they can provide an enormous amount of information regarding the mechanisms, e.g., the transport of gas from the disk into the nuclear region, which trigger and sustain the starburst. H I observations contribute strongly to the understanding of the overall evolution of starburst galaxies. In particular, high-resolution H I absorption measurements reveal a large amount of cold neutral atomic gas in the nuclear region of starburst galaxies, mixed within molecular gas and H II regions, and rotating at rather high speed around the central mass concentration. A specific aim of this study is to understand the behaviour of the rotating curve in the nuclear region of galaxies.

Additional information on the above projects can be found in my home page at http://www.atnf.csiro.au/people/bkoribal

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