The Warped Gas and Dust Lane in NGC 3718

NGC 3718

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Abstract. We present the first observations of molecular line emission in NGC 3718 with the IRAM 30m and the Plateau de Bure Interferometer. This galaxy is an impressive example for a strongly warped gas disk harboring an active galactic nucleus (AGN). An impressive dust lane is crossing the nucleus and a warp is developing into a polar ring. The molecular gas content is found to be typical of an elliptical galaxy with a relatively low molecular gas mass content ($\sim 4 \times 10^8 M_\odot$). The molecular gas distribution is found to warp from the inner disk together with the HI distribution. The CO data were also used to improve the kinematic modeling in the inner part of the galaxy, based on the so-called tilted ring-model. The nature of NGC 3718 is compared with its northern sky “twin” Centaurus A and the possible recent swallowing of a small-size gas-rich spiral is discussed.

Keywords: galaxies: individual: NGC 3718 – galaxies: active – galaxies: kinematics and dynamics – ISM: molecules

NGC 3718 is a peculiar galaxy at a distance of 13 Mpc. The most prominent features of this galaxy are its large, warped dust lane running across the entire stellar bulge of the galaxy. The galaxy NGC 3718 (Arp 214) and its companion NGC 3729 form a galaxy pair, at a distance of about 13 Mpc as part of the Ursa Major Galaxy Cluster. In addition NGC 3718 and NGC 3729 were classified as members of Group 241 in the LGG (Lyon group of galaxies catalog). Both the cluster and the group are poorly defined, with velocity dispersions of less than 150 km s$^{-1}$. Such a low velocity dispersion is an indication, that cannibalism of small galaxies is quite likely.

The galaxies are also contained in the Hubble Atlas of Galaxies and the Atlas of Peculiar Galaxies, where the extremely dark dust feature and a relatively small nucleus of NGC 3718 become apparent. NGC 3718 shows its very peculiar optical appearance, with the prominent dust lane, covering a large part of the galaxy’s main body. It starts with a width of less than 2 arcsec at the center and extends into several smooth filaments across the bulge of the galaxy. At a separation of about 1.5 arcmin from the nucleus they bend by almost 90 degrees towards the north and the south and remain visible over a distance of more than 6 arcmins (24 kpc). Inspection of the dust lane shows that the warp signature goes all the way into the center of the galaxy (Fig.1).

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1 Throughout this work we assume $H_0=75$ km s$^{-1}$ Mpc$^{-1}$

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Figure 1. left panel: Optical image of NGC 3718. Taken from the DSS survey. right panel: The optical image, overlaid with the contours (linear scale-steps of $\sigma \sim 0.3 K$ km s$^{-1}$) of our CO(1-0) observations. The warp of the molecular gas distribution is as obvious as the coincidence of gas and dust lane.

The warp is also present in the atomic gas and has been kinematically modeled by Schwarz (1985).

NGC 3718 contains an active nucleus. Ho et al. (1997) classified NGC 3718 as both a LINER and a Seyfert 1.9 galaxy. The nucleus shows weak, broad H$\alpha$ emission with FWHM= 2350 km s$^{-1}$. Filippenko et al. (1985) report strong [O I] $\lambda$ 6300 with FWHM= 570 km s$^{-1}$ indicative for a hidden AGN (Ho et al. 1997). Burke & Miley (1973) found a radio source at the position of the nucleus of NGC 3718, reporting a 1415 MHz flux density of $(20 \pm 5) \cdot 10^{-29}$ Wm$^{-2}$Hz$^{-1}$. The radio emission is at the lower end of the range of Seyfert galaxies, but exceeds that of most normal galaxies. Using the HST, Barth et al. (1998) searched for ultraviolet emission in LINER galaxies and did not detect NGC 3718. A possible explanation could be that the UV sources are obscured by dust, which is reasonable in the case of NGC 3718. From its optical appearance and the large scale dynamics NGC 3718 can be regarded as the northern hemisphere counterpart of Centaurus A. In Centaurus A also a warping of the molecular gas disk in the inner 1 kpc is invoked to explain its dust lane and the associated complex kinematics (Sparke 1996, Quillen, Graham, and Frogel 1993, and Quillen et al. 1992).

The HI maps (Schwarz 1985) show a depletion of HI gas towards the central arcminute right on the dust lane. This is probably the location were - like in Cen A (Eckart et al. 1990, Wild, Eckart, Wiklund 1997) - the molecular gas takes over and becomes the dominant component of the neutral (atomic and molecular) ISM.
Figure 2. A summary of recent Plateau de Bure observations on CO(1-0) line emission towards NGC 3718.

To understand the evolution of galaxies it is essential to study the dynamics of the molecular gas. It is believed that the formation of bulges is coupled to gas relocation due to a barred potential. For the fueling process of the nuclear activity like Active Galactic Nuclei (AGNs) or nuclear starbursts, the molecular gas has to be moved from large radii (kpc-scale) to a few parsecs. Therefore it is important to understand the responsible transport mechanism i.e. to investigate structure and kinematics of the atomic and molecular gas. How gas may easily be transported towards the center of such disks has recently been shown by Duschl et al. (2000). The authors suggest that viscosity within such gaseous disks may provide an efficient AGN fueling mechanism.

In the course of our ongoing study of the dynamics of active galaxies NGC 3718 is a special case. Its gas dynamics on kpc scales is dominated by a strong warp possibly due to interaction with an outer galactic halo. Recent observations of H$_2$O masers near the central engine in two nearby Seyfert galaxies show that the central 1 pc disks are warped. Our recent result of our high angular ($\sim 0.7''$) interferometric data on nearby Seyfert galaxies indicate that the CO gas in the inner 500 pc might be warped as well (Schinnerer, Eckart & Tacconi 2000a, Schinnerer et al. 2000b, Eckart & Downes 2001). A detailed modeling of the molecular gas as seen using the IRAM 30m telescope and the Plateau
de Bure Interferometer (Fig.2) has been carried out and is described in detail in a forthcoming paper by Hartwich et al. (2002) and Krips, Pott et al. (2002).

Here we present shortly the most important results:

(i) Based on our high resolution data of the molecular gas, we could observe, that also the inner gas disc is warped down to 20", which was unresolved by the model of Schwarz (1985), but is consistent with the newer HI-data of Verheijen & Sancisi (2001), conducted with a comparable small beam size at the WSRT.

(ii) We estimated a rotation curve, corrected for the inclination of the tilted gas rings, which is constant \( (235 \pm 15 \text{ km s}^{-1}) \) between 20" and 100", i.e. the central region, where the molecular gas is the dominant partition of the neutral gas.

(iii) Our model explains the observed warp-features of the integrated line-intensity map (Fig.1) and of the pv-diagram along a PA=-66degr convincingly as orbit crowding and transits smoothly to the model of the outer HI by Schwarz (1985).

High resolution kinematical three dimensional models of the gas distribution as the one presented in Hartwich et al. (in prep.) can help to understand the causes for the found warp and the history of the galaxy by analyzing the evolution of the precessing gas rings of the tilted ring-model.

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