On the Interaction in a Quartet of Galaxies

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Abstract. We performed the Fabry-Perot scanning interferometry of the quartet of galaxies NGC 7769, 7770, 7771 and 7771A in Hα line and studied their velocity fields. We found that the rotation curve of NGC 7769 is weakly distorted. The rotation curve of NGC 7771 is strongly distorted with the tidal arms caused by direct flyby of NGC 7769 and flyby of a smaller neighbor NGC 7770. The rotation curve of NGC 7770 is significantly skewed because of the interaction with much massive NGC 7771. The rotation curves and morphological disturbances suggest that the NGC 7769 and NGC 7771A have passed the first pericenter stage, however, probably the second encounter has not happened yet.

1. Velocity fields and rotation curves

We report the results of the optical interferometry of the interacting system of galaxies NGC 7769, 7770, 7771 and 7771A and analyze their kinematics. A detailed description of the morphological features of the galaxies as well as photometry and color analysis of NGC 7769 are presented in the complete version of the study: Yeghiazaryan et al. (2015). We also discuss the influence of interaction on the kinematics, dynamics and star formation in the system. Known models of galaxy interactions are based mostly on statistical observational data. We try to illustrate how and to what extent these models can be applied to explain the features of the galaxies in this system.

In order to study the velocity fields of the galaxies, the observations were carried out at the 2.6m telescope of the Byurakan Astrophysical Observatory (BAO, Armenia) on 8 November 1996, with the ByuFOSC (Byurakan Faint Object Spectral Camera) in the interferometric mode, attached at the prime focus of the telescope.

Based on the Hα velocity fields (the right-hand panels of Figure 1), we calculated the rotation curves of the galaxies (the left-hand panels of Figure 1) by using data points within sectors along the maximal gradient direction, see isovelocity contours in the right-hand panels of Figure 1.

Maximal rotational velocity of NGC 7769 is observed at the radius of around 15 arcsec from the galaxy nucleus. The rotational velocities in Figure 1 are in good agreement with the HI measurements (316 km s⁻¹) in Chengalur et al. (1993). Our measurements of velocities, having a better spatial resolution compared with those of the previous studies (Chengalur et al. 1993; Nordgren et al. 1997), reveal weak perturbations of the rotation curve of NGC 7769, which may be caused by interaction with NGC 7771.

The same cannot be said about the velocity field of NGC 7771. Figure 1 shows that there are perturbations and large dispersion in radial velocities at the distances...
larger than about 10-15 arcsec from the nuclei. This distance is about half radius of the bar. Evidently, this scatter of radial velocities can be explained by the fact that part of the arms are included in the sector used to calculate radial velocities (sector angle is 40°). However the asymmetric profile along the major axis suggests that Northern and Southern arms do not have the same radial velocity profiles. The asymmetric tidal forces of NGC 7769 and NGC 7770 affecting on NGC 7771, seem to be a natural cause of that.

The rotation curve of NGC 7770 is significantly skewed. This is probably because of the strong harassing interaction with the more massive NGC 7771, see Alonso-Herrero et al. (2012). The rotation curve of NGC 7771A is typical for a late type Sm galaxy.

Figure 1. Right: Hα velocity fields of galaxies NGC 7769, 7770, 7771 and 7771A, overlapped by the SDSS r-band isophotes (black), and isovelocity contours (white). The outer isophote corresponds to 22 mag arcsec\(^{-2}\) for NGC 7769, 7770 and 7771, and to 23 mag arcsec\(^{-2}\) for NGC 7771A. Left: Derived rotational curves of the galaxies. One pixel on the horizontal axis corresponds to 0.77 arcsec. For each plot, the radial velocity of the galaxy center, the angle and PA of the sector used to obtain velocity data, as well as the inclination of galaxy used in the calculations are shown.
By analyzing velocity fields, sizes, and shapes of spiral arms of NGC 7771 and NGC 7769, in Nordgren et al. (1997) it has been suggested that NGC 7771 and NGC 7769, which have a 2:1 mass ratio, appear to be having a prograde-retrograde interaction, with NGC 7769 being the retrograde one. Our better data support this conclusion. This conclusion is in agreement with the latest models of galaxy collisions (Di Matteo et al. 2007) showing that during direct collisions tidally induced spiral arms are much longer and brighter than those during retrograde collisions. We can conclude that galaxies NGC 7769 and NGC 7771 already have passed the first pericenter stage, however, probably the second encounter has not happened yet. The first pericenter distance should have been large enough (around few sizes of the galaxies), so that large disturbances in rotation curves have not appeared yet.

2. Summary

The quartet of galaxies NGC 7769, 7770, 7771 and 7771A is a system of interacting galaxies. Here, we present a Fabry-Perot imaging study of the system in Hα line. We came to the following main conclusions:

- Close interaction between the component galaxies of the system has produced morphological features that are characteristic of the interactions. We have detected features such as tidal arms, spiral arms induced by close interaction, bars and induced star formation.

- From the results of our interferometric observations, we obtained the radial velocity profiles of galaxies. The rotation curve of NGC 7769 is weakly distorted. The rotation curve of NGC 7771 is strongly distorted by the tidal arms caused by direct flyby of NGC 7769 and flyby of a smaller neighbor NGC 7770. The rotation curve of NGC 7770 is significantly skewed because of the interaction with much massive NGC 7771.

- The radial velocity profiles and morphological disturbances suggest that the NGC 7769 and NGC 7771 have passed the first pericenter stage, however, probably the second encounter has not happened yet.

Study of such systems with methods combining photometric and visual analysis is an effective way to clarify features of star formation in different stages of interaction. Ongoing and future surveys using integral field spectroscopy will allow also to explore the spatial distribution of star formation in interacting systems.

References

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Yeghiazaryan, A. A., Nazaryan, T. A., & Hakobyan, A. A. 2015, arXiv:1510.00193