Helical structures in Seyfert galaxies

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Abstract. The Seyfert galaxies with Z-shaped emission filaments in the Narrow Line Region (NLR) are considered. We assume that observable Z-shaped structures and velocity pattern of NLR may be explained as tridimensional helical waves in the ionization cone.

1. Introduction

The numerous emission line images of Seyfert galaxies show a existence of a cone-like NLR with a broad opening angles and spatial sizes from 10 pc to 18 kpc (Wilson & Tsvetanov 1994). Also these galaxies has high-collimated elongated radio structures (radio-jets) coinciding with the cones axis (Wilson & Tsvetanov 1994; Nagar et al. 1999). A ordered Z-shaped emission pattern is a frequently features in the NLRs. We found more then 20 such objects on published emission-line images of the nearby Seyferts. There are no common point of view on an origin of the such regular structures in NLR. Different models were proposed for individual objects: a bent bipolar outflow (Mulchaey et al. 1992), strong collimated precessing twin-jet (Veilleux, Tully, & Bland-Hawtorn 1993), a system of inclined gaseous disks (Morse et al. 1998) and etc.

2. Kinematical features of the Z-shaped NLR

A sample of galaxies with Z-shaped NLRs were observed at the 6m telescope. The scanning Interferometer Fabry-Perot and integral field spectrograph MPFS were used for study of the 2D kinematics of stars and ionized gas. Some systems of the gas clouds with velocity difference more than $100 \div 200 \text{ km s}^{-1}$ are present on the light of sight in the central region of cones, but the outer emission filaments has only one component of the emission lines. The gas velocity fields are strongly non-circular in comparing with the stellar one. A large gradient of the line of sight gas velocities presents in Z-shaped spiral. We note that similar features also observed on the velocity fields in the other Sy galaxies with (see references in Moiseev et al. 2000) and these could be common for Z-shaped pattern.
3. Non-linear simulations

We suggest that Z-shaped spiral filaments in NLRs have a common wave origin and generated by the hydrodynamic instability due to the velocity break between a galactic instellar medium and a outflowing gas from the central AGN. A collimated radio jet corresponds to the direction of outflow and matches with the cone’s axis. A linear analysis shows that jet are unstable relatively to waveguide-resonance development of pinch and helical internal gravity waves. A developments of the instabilities leads to a set of shock waves creation in an ambient medium. Our 2D and 3D non-linear hydrodynamical simulations show that the shock waves penetrate outward from the jet boundaries to the ambient medium. A resulting shock-wave structure covers broad cone with open angle $30^\circ \div 80^\circ$ and appears in a sky-plane as a NLR with bright emission pattern (Fig. 1). A pinch (axisymmetrical) and helical modes of the shock waves are develop in the NLR. A helical wave modes provides the Z-shaped emission structures which observed in the ionized cones.

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References