Black Holes from Stars to Galaxies – Across the Range of Masses
Proceedings IAU Symposium No. 238, 2006
V. Karas & G. Matt, eds.

doi:10.1017/S1743921307005352

Relationship between X-shaped radio sources and double-double radio galaxies

Xian Chen and Fukun Liu

Department of Astronomy, Peking University, 100871, Beijing, China
email: fkliu@bac.pku.edu.cn

Abstract. Both the X-shaped radio galaxies and double-double radio galaxies (DDRGs) are suggested in the literature to be due to the binary-accretion disk interaction or to the coalescence of SMBBHs. These models suggest some relationship between the two types of radio sources. In this paper, we collected data from literatures for two samples of X-shaped and double-double radio galaxies together with a control sample of FRII radio galaxies and statistically investigate their properties.

We find that the wings of X-shaped radio galaxies and the outer and inner lobes of DDRGs tend to be perpendicular to the major axis of the host galaxy (or dust structures), while the active lobes orient randomly. Both X-shaped and double-double radio galaxies are low luminous FRII or FRI/FRII transitional radio sources with the similar dimensionless accretion rate $\dot{m} \sim 0.01$, which is about the transitional accretion rate given in the literature.

All the statistic results can be reconciled if there is an evolutionary relationship between X-shaped and double-double radio galaxies, in the sense that X-shaped radio galaxies may be due to the interaction of active SMBBHs and accretion disk and DDRGs due to the removal of inner disk region and the coalescence of SMBBHs.

Keywords. Accretion, accretion disks – black hole physics – galaxies: active – galaxies: interactions – galaxies: jets

1. Introduction

Supermassive binary black holes (SMBBHs) at galactic centers are expected by the hierarchical galaxy formation model in cold dark matter (CMD) cosmology (Haehnelt & Kauffmann 2000; Kauffmann & Haehnelt 2000). Both the X-shaped radio galaxies and double-double radio galaxies (DDRGs) are suggested in the literature to be due to the binary-accretion disk interaction or to the coalescence of SMBBHs (Merritt & Ekers 2002; Liu *et al.* 2003; Liu 2004). These models suggest some relationship between the two types of radio sources. In this paper, we statistically investigate the observations of the two types of radio sources and discuss the implications to different models.

2. Method

We collected the observational data of radio power, linear size and projected position angles of radio feature and host galaxy for two samples of X-shaped and double-double radio galaxies and a control sample of FRII radio galaxies. We also estimated the central black hole mass and bolometric luminosity, and calculated the dimensionless accretion rate. We investigated the distributions of the three samples sources by employing the K–S test.

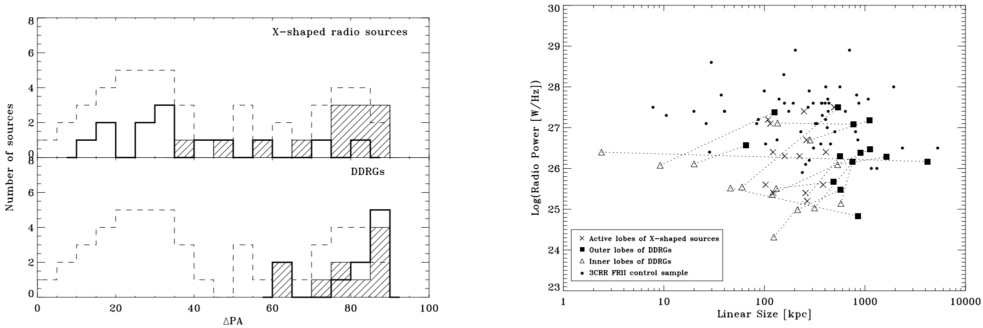

Figure 1. Left: Distributions of relative position angles (ΔPAs). The thin dashed line is for 3CRR control sample. The thick solid line and the shaded area are, respectively, for active lobes and wings of X-shaped radio sources (upper panel) and for the inner and outer lobes of DDRGs (lower panel). Right: Linear sizes of radio structures vs. radio power of the samples. Radio power is in W Hz^{-1} at 178 MHz. Cross is the active lobes of X-shaped radio sources. Squares and triangles are, respectively, the outer and inner lobes of DDRGs and, if belong to the same object, are connected with a dotted line. Dots are 3CRR control sample sources.

3. Results

The relative position angles between different radio structure and the major axis of host galaxy are presented in the left panel of Fig. 1. It is clear that the wings of X-shaped radio galaxies and the outer and inner lobes of DDRGs tend to be perpendicular to the major axis of the host galaxy (or dust structures), while the active lobes orient randomly.

The linear size and radio power of the sample sources are presented in the right panel of Fig. 1. It shows that both X-shaped and double-double radio galaxies are low luminous FRII or FRI/FRII transitional radio sources. The inner lobes of DDRGs and the active lobes of X-shaped radio sources have similar radio extension, but the outer lobes of DDRGs are significantly larger than wings of X-shaped radio sources. We also find that both types of sources have the similar dimensionless accretion rate $\dot{m} \sim 0.01$, which is about the transitional accretion rate given in the literature.

4. Conclusion

Our results are consistent with the scenarios for X-shaped and double-double radio galaxies that the X-shaped feature in winged sources is due to swift jet reorientation and the double-lobed radio structure in DDRGs is due to the interruption of jet formation. All the statistic results can be reconciled if there is an evolutionary relationship between X-shaped and double-double radio galaxies, in the sense that X-shaped radio galaxies may be due to the interaction of active SMBBHs and accretion disk and DDRGs due to the removal of inner disk region and the coalescence of SMBBHs.

Acknowledgements

This work is supported by the National Natural Science Foundation of China (NSFC 10573001).

References

Haehnelt, M. G. & Kauffmann, G. 2000, MNRAS, 318, L35
Kauffmann, G. & Haehnelt, M. G. 2000, MNRAS, 311, 576
Liu, F. K. 2004, MNRAS, 347, 1357
Liu, F. K., Wu, X. B. & Cao, S. L. 2003, MNRAS, 340, 411
Merritt, D. & Ekers, R. D. 2002, Science, 297, 1310

https://doi.org/10.1017/S1743921307005352 Published online by Cambridge University Press