MODELLING THE GRAVITATIONAL LENS OF THE DOUBLE QUASAR

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The discovery of the double quasar (Walsh et al. 1979) provides an opportunity to study the mass distribution of elliptical galaxies and clusters of galaxies. This has been done initially by Young et al. (1981) who produced a model to account for the image positions and intensities. Since then VLBI observations have been made of 0957+561A and B (Porcas et al. 1981) which show very similar core and jet structures in the nuclei of both images. In addition to providing further evidence in favour of the gravitational lens hypothesis, these new observations provide additional constraints on the mass distribution of the lensing galaxy and cluster. We have attempted to produce a model in the light of these new results.

Due to the low flux density of this source it has not been possible to make VLBI maps of the two images. Instead a process of model fitting was used. The most reliable quantities from this process are the relative positions of the core and jet in each image. Individual flux densities and sizes for the core and jet are prone to uncertainty due to poor u-v coverage. Consequently we only tried to reproduce the observed jet-core separations of

$$\underline{\Delta\theta_A} = (0''.016,\ 0''.043)$$

and

$$\underline{\Delta\theta_{B1}} = (0''.016,\ 0''.054)$$

with our model of the mass distribution.

We have investigated many different models using a method similar to that described by Young et al. (1981). Our most successful ones consist of two elliptical King distributions; one for the dominant galaxy (G1) and one for the rest of the cluster material. The following is the best model we have found so far.

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	Galaxy (G1)	Cluster
Position of centre	(0$''$.0, 0$''$.0)	(-2$''$.0, -5$''$.0)
Structural length	0$''$.13	13$''$
Velocity dispersion	280 km s^{-1}	920 km s^{-1}
Axial ratio	0.76	0.4
Position Angle	48°	73°

QSO core position (-0$''$.1676, -2$''$.2865)
QSO jet-core separation (0$''$.0089, 0$''$.0252)

The coordinate system has x along the direction of increasing right ascension and y along the direction of increasing declination, structural lengths are defined as core radius/3, and position angles are defined from North through East. We have used values of H_0 = 60 km s^{-1} Mpc^{-1} and q_0 = 0. This model produces three images with the following positions, amplification factors and jet-core separations:

	Position	Amplification	Jet-core separation
A	(-1$''$.435, 5$''$.066)	3.573	(0$''$.015, 0$''$.047)
B1	(-0$''$.205, -1$''$.007)	-2.384	(0$''$.014, 0$''$.049)
B2	(-0$''$.021, -0$''$.298)	0.209	(-0$''$.006, -0$''$.017)

This results in the following image flux ratios:

B1/A	-0.667
B2/B1	-0.088

This model is in reasonable agreement with observation except perhaps for the amplification factor for image B2 which is rather large. In the absence of a measured value for the flux density of B2 we must ensure that our model does not produce too bright a third image. Our present model requires that all of the flux from component G on the VLA map of Greenfield et al. (1980) be due to the image B2 and none to the galaxy G1. We are currently trying to modify our model to produce a smaller amplification factor for image B2.

It thus seems likely that all of the observations of the double quasar can be explained by a gravitational lens consisting of an elliptical galaxy in a cluster. However, in order to accommodate the VLBI results we have to modify some of the galaxy or cluster parameters originally proposed by Young et al. (1981).

References

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