A SUMMARY OF THE OBSERVATIONS OF THE TWIN QSOs, 0957+561 A,B

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ABSTRACT

An analysis of all observations of the "twin" QSOs, 0957+561 A,B, to date does not yet allow us to distinguish between their being two nearly identical QSOs or a single QSO split into two images by an intervening gravitational lens. The more identical the two objects are found to be, the more difficult any explanation which postulates the existence of two distinct QSOs becomes. Jodrell Bank and VLA observations reveal additional radio structure to the northeast of the northern QSO image which, if physically associated with a single QSO doubly imaged by a gravitational lens, would itself be imaged weakly to the southwest. More detailed radio mapping should be able to test the existence of such an image.

The VLBI map of Porcas and his collaborators reveals that the radio images corresponding to the optical ones are point sources separated by 6.175 arcsec having an angular extent to less than 20 milliarcseconds, whereas all further radio structure is resolved out.

Optical spectroscopy of the twins reveals two nearly identical sources with indistinguishable emission line redshifts and with absorption line redshifts identical to within 15 km/sec. It is the identity of these optical characteristics which makes all non-gravitational lens hypotheses most difficult.

The most compelling test of the lens hypothesis is the measurement of time variations of the two images at as many wavelengths as

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possible. If brightness variations of one image are repeated by the other after a time interval determined by the details of the observer-lens-QSO geometry (such an interval could be of the order of many months or years) the lens hypothesis would be confirmed. Several observations indicate prior variations of the images, and programs to monitor their relative brightness in the future will be of great importance.

DISCUSSION

D. Roberts: If the extended radio emission in the map I presented is either foreground or background, then one might expect it to have a compact component. Do you know if Walsh et al. have seen such a source in their VLBI? Also, is it not true that the object which seems to have undergone the greater reddening shows the shallower absorption lines, contrary to what one might have expected?

Chaffee: The VLBI map of Porcas et al. shows only the two QSOs as compact sources. No compact component is associated with the structure seen to the northeast.

It is true that the redder object seems to have shallower absorption lines.

H.E. Smith: What is the shortest time lag between the objects' variability that you would consider reasonable? (I.e., if William Liller were to see only one outburst, with a fairly short duration, could that eliminate the lens hypothesis?)

Chaffee: The time lag depends sensitively on the distance to the deflecting mass and to its alignment. If we place the mass at $z = 0.7$ (half the redshift of the QSO), the time lag is a few months. The farther away from us the mass is, the longer the time lag. The brightening of one image without the subsequent brightening of the other does not rule out the lens hypothesis because if the mass is close to the QSO that lag can become very long. The most convincing proof of the lens hypothesis would be for one image to vary in intensity in some characteristic way (a flickering of some kind, say) and some months later have the other image mimic that signature. It remains to be seen if nature will cooperate.

Epstein: Comment regarding the presence of tertiary optical images: At Montreal there was shown a radio map indicating the presence of a tertiary image. Dr. Barnothy pointed out that tertiary images are not unexpected under the gravitational lens hypothesis.

How did you arrive at the estimate of the time scale of variability to be expected if there is a gravitational lens present?

Chaffee: The time scale of variations depends on a large number of parameters -- most importantly, the distance to the deflecting mass, its mass distribution and its angular displacement from the line of sight to the QSO. Our estimate is based on arbitrarily placing the mass at half the redshift of the QSOs, making reasonable assumptions concerning the mass distribution (i.e., the velocity dispersion) in the deflector and using the estimate that the deflector is 0.4 arc sec off the line of sight, which follows directly from the relative brightness of the two images.

Marscher: I'd like to comment that the detection of a single (rather than a double) X-ray source would not convincingly rule out a gravitational lens. If the X-ray flux is highly variable -- sometimes detectable, sometimes not -- then the differential light travel time could cause each source to "blink" out of phase with the other.

B. Wills: Concerning the interpretation of the division of the two spectral scans of 0957+561 A and B: the fact that the emission lines divide out completely means that, to quite a high degree of accuracy, the equivalent widths, not the intensities, are the same in both components. This means that if the objects are due to a gravitational lens, the differences in the continua must be due to some kind of extinction -- equally affecting the emission lines.

Do the deep plates show any other features of interest in the region of the double QSO (e.g., at the positions of other features in the radio maps or which could be attributed to galaxies)?

Chaffee: The video camera observations with the Kitt Peak 4-meter telescope by Adams and Boroson, which will be published in Nature later this fall, show eight non-stellar objects in a 75 x 75 arc sec field centered on the twins. None of their positions corresponds to the excess radio emission, presented by Roberts in the preceding paper, to the northeast of the twins.

M. Burbidge: Dr. Wills, how much differential extinction would that correspond to?

B. Wills: The differential extinction amounts to $A_V = 0^m.5$, and is almost independent of the distance of the absorber ($1 \leq z \leq 1.4$).

G. Burbidge: Is there any bright galaxy nearby? The difficulties that you raised with the idea that it is two separate objects at a cosmological distance, namely the large energy and the similarity of the absorption over ~ 70 kpc, are reduced by a large factor if the objects are at a distance about 50 times less than the cosmological distance.

Chaffee: There is a bright irregular galaxy 10 arc min to the southeast of the twins.

Naturally, many of the problems I have discussed in explaining the existence of the identical QSOs would be eased if they were closer than cosmological distances from us.

Koo: In light of the provocative presentation by Dr. G. Burbidge, has a search been made for a nearby galaxy and additional QSOs?

Chaffee: A bright galaxy does exist 10 arc min to the southeast, and a number of faint ones have been detected by Adams and Boroson nearer the QSOs. No search has yet been made for other QSOs in the field nearby.

No optical polarization measurements have yet been made.

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