SUPERLUMINAL MOTION IN NRAO 140 AND A POSSIBLE FUTURE METHOD FOR CONSTRAINING H_o AND q_o

Alan P. Marscher
Center for Astrophysics and Space Sciences, UCSD

John J. Broderick
Department of Physics, VPI & SU

NRAO 140 is a quasar (z = 1.258) which is among only 3 or 4 such objects (and the one with the highest z) which were detected at X-ray energies prior to the operation of the Einstein Observatory (Marscher et al. 1979). We obtained contemporaneous X-ray and radio VLBI observations of the source in early 1980, to determine whether Compton scattering within the radio source is the primary X-ray emission mechanism (Marscher and Broderick 1981b). Instead, we found that the radio parameters predicted more than 10^3 times more X-ray flux than was observed. Since the Compton calculation is independent of distance, and since the troublesome component was partially resolved (and hence not a high-brightness-temperature emitter), we found that relativistic motion aimed nearly directly toward the observer with Lorentz factor exceeding 4, needed to be invoked in order to bring the predicted Compton flux down to the observed level (Marscher and Broderick 1981a, b). Since relativistic motion is also the preferred explanation for the apparent superluminal expansion seen in some compact radio sources (e.g., M. Cohen, this volume; Marscher and Scott 1980; Kellermann and Pauliny-Toth 1981), we predicted that the compact components in NRAO 140 should appear to separate at a speed exceeding about 4c.

We have obtained further VLBI observations of NRAO 140 at 2.8 cm in February 1981 and June 1981, in order to test this prediction. The correlated flux densities and closure phases show clear, systematic changes compared with the April 1980 data. We find that these changes are modeled (both by hybrid mapping and by model fitting) very well by an increase in the separation of the compact components by 0.09 to 0.16 milliarcseconds (mas), which corresponds to an angular separation rate of 0.08 to 0.14 mas/yr. For cosmological distances and $H_o = 50$ and $q_o = 0$, these rates in turn correspond to velocities of separation which range from 6.7c to 12c; for $H_o = 100$ and $q_o = 1$, the range is 2.1c to 3.7c. Since our prediction that motions should exceed 4c can be taken only as an approximation owing to the possibility that the viewing angle may not be the optimum one for superluminal motion, even H_o and q_o as high as these latter values are consistent with the constraints imposed by the observed-versus-predicted X-ray flux. We also stress that the

D. S. Heeschen and C. M. Wade (eds.), Extragalactic Radio Sources, 359–360.

https://doi.org/10.1017/S007418090002814X Published online by Cambridge University Press

observed increase in separation of the components is less than 10%; further VLBI monitoring is necessary in order to determine the separation rate more precisely.

From these results, we can outline a prescription for the determination of upper limits to the cosmological parameters H_o and q_o. To use this method, one needs a dedicated VLB array and an orbiting X-ray observatory (such as the proposed AXAF) with sensitivity at least as good as that of the Einstein satellite. One first observes, contemporaneously with the X-ray satellite, a large number of quasars over a wide range of redshifts, with the VLB array at several frequencies. One then picks out those quasars (one hopes that a large enough group exists!) for which the predicted Compton X-ray flux far exceeds the observed value. One can calculate the minimum values of bulk Lorentz factors γ needed to bring the predicted X-ray fluxes down to the observed values. One then observes this group of objects for at least two years to determine the apparent velocity of separation of the components for each source. After one does a suitable average over angles of ejection relative to the line-of-sight, the mean ratio (min. γ from Compton arguments)/(γ required to explain separation velocity; function of H_o, q_o), can be determined. Quasars of similar redshift would yield an upper limit to H_o by the requirement that this ratio exceed unity. Quasars at different redshifts would allow one to place an upper limit on q_o by this method.

A.P.M. was an Einstein (HEAO 2) Guest Investigator, and was supported by NASA and the NSF. J.J.B. also gratefully acknowledges funding by the NSF.

REFERENCES

Kellermann, K. I., and Pauliny-Toth, I.I.K. 1981, Ann. Rev. Astron. Astrophys., in press.
Marscher, A. P., and Broderick, J. J. 1981a, Ap. J., 247, L49.
Marscher, A. P., and Broderick, J. J. 1981b, Ap. J., 249, in press.
Marscher, A. P., et al. 1979, Ap. J., 233, 498.
Marscher, A. P., and Scott, J. S. 1980, P.A.S.P., 92, 127.

https://doi.org/10.1017/S007418090002814X Published online by Cambridge University Press