DUAL RELATIVISTIC EFFECTS IN COMPACT RADIO SOURCES

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ABSTRACT. Dual relativistic effects in compact radio sources are discussed, and as an illustrative example we try to show that the observed features of the knot C_4 in 3C345 (superluminal motion, superluminal expansion, apparent diameter and flux variation etc.) can be interpreted simultaneously.

Recent VLBI observations have shown that in the superluminal source 3C345 knots C_4 and C_2 are moving and expanding superluminally (Readhead(1984), Biretta(1985)). This dual apparently superluminal phenomenon may essentially be an evidence for the dual relativistic effect which we have introduced in the study of compact radio sources (Qian(1983), Qian et al.(1985)). We have shown with plasmon models that the dual relativistic effect is very promising in explaining the superluminal flux variations with time scales of 1-10 days at short centimeter wavelengths observed in certain compact sources. In favourable conditions it can increase significantly the probability of seeing a superluminal motion. The Lorentz factors required are moderate and in the range of the observed ones. Here we try to interpret the observed features of knot C_4 (as an illustrative example) in terms of dual relativistic plasmon model. The following observational facts, arguments and simplifications are taken into account in order to choose a reasonable set of parameters: (1) Although knot C_4 may presumably have a curved path very close to the core, its positions since 1980.5 (the epoch of first VLBI observations at 10.7GHz) can be fitted to straight line motion quite well; (2) For simplicity, we assume that the motion of C_4 is uniform during the period of 1980-1984, its apparent velocity V_a is taken to be 5.5c; (3) However, we suppose that knot C_4 would accelerate to an apparent velocity of ~10c similar to that of C_2 when it reaches distances of 5-6 mas to the core. A favourable evidence for this may be the similarity between the responsible outbursts at 10.7GHz, if their dynamic properties are considered to be dependent on their energetics. Thus we argue for its viewing angle θ being less than 12°, and we assume

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 89–90.

$\theta = 8^\circ$;(4)According to the VLBI observations,the apparent expanding velocity V_d is taken to be 1.4c;(5)From inverse compton argument and X-ray observations the Doppler factor δ_x of C4 should be greater than 7.0;(6)Knot C4 is optically thin at 10.7GHz and 22.2GHz;(7)The energy spectral index is taken to be 1.0,i.e. in the reference system fixed to the centre of plasmon the electrons have a power law energy spectrum $N(E) = N_0E^{-1}$.

From points (1)-(4),we would assume that the bulk-motion velocity $V_b = \beta c$, β =0.9847 (γ_β =5.74 and $\delta_\beta = (\gamma_\beta(1-\beta\cos\theta))^{-1}=7$ agreeing with point (5));the expansion velocity in the centre-fixed system is taken to be $V_e = \alpha c$, α =0.20 because of $V_d=\alpha\gamma_\alpha\delta_\beta$. Considering that the outburst started between 1979 and 1980,we derive the apparent diameter in 1983-1984 to be $\sim$1.7pc which agrees with the observed ones.From point (6),particle acceleration and field amplification should be taken into account in order to explain the rising phase of the outburst.For simplicity we assume that in the centre-fixed reference system $N_0=N_{00}t^{-n}$ and $H_0=H_{00}t^{-m}$ with $n>0, m<0$ (in the rising phase $t<t_*$) and $m>0$ (in the declining phase $t\geqslant t_*$);see Pacholczyk and Scott(1976).We choose $n=3.0, m=-1.7$ ($t<t_*$) and $m=1.7$ ($t\geqslant t_*$), $N_{00}=0.25$, $H_{00}=3\times10^{-6}$G and $t_*=25$yr.The flux variation calculated for C4 is shown in Fig.1 which is consistent with the observations quite well. A characteristic of the model is that at the start of the outburst the electron energy is far greater than the field energy, but when $t\sim t_*$ it reaches towards the energy equipartition.

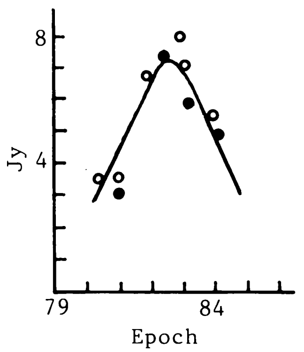

Fig.1. Flux variation of knot C4(• 22.2GHz, ∘ 10.7GHz).

It can be seen from above, our model can simultaneously explain most of the observed features of knot C4:superluminal motion(5.5c),superluminal expansion(1.4c),apparent diameter(1.7pc),large angle subtended at the core(28°),flux variation time scales and spectral evolution.Only the accelerated motion and its effects remain to be studied.

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https://doi.org/10.1017/S0074180900134060 Published online by Cambridge University Press