A MULTI-RADIO-FREQUENCY STUDY OF A RQQ

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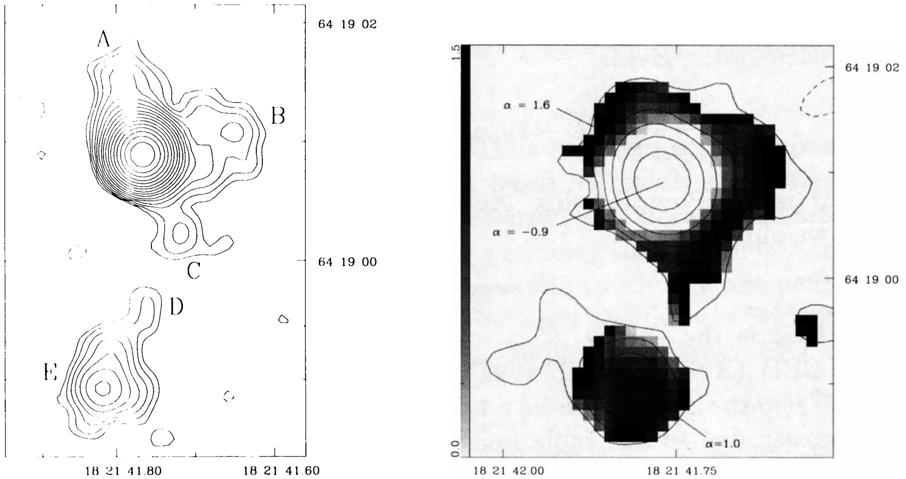

Figure 1. ***Left:*** **E 1821+643 at 8.0 GHz; the circular beam has FWHM of 0.3″. The solid contour levels are logarithmic with ratio $\sqrt{2}$; the bottom contour is at 0.048 mJy/beam and the top contour is at 8.67 mJy/beam. A dashed contour is plotted at −0.048 mJy/beam.** ***Right:*** **A map in spectral index between 5 and 8 GHz. Contours in total intensity at 5 GHz are overlaid. The contours are logarithmic with ratio 2; the bottom contour is 0.12 mJy/beam and the top contour is 6.4 mJy/beam. The greyscale shown runs from $\alpha = 0$ (white) to $\alpha = 1.5$ (black). Regions within the two lowest contours which are white have $\alpha < 0$; other white regions have been masked. (We use the convention that $S_\nu \propto \nu^{-\alpha}$.)**

1821+643 is exceptionally bright at optical wavelengths with $M_{\rm B} \approx -27$ (Hutchings & Neff 1991), at a redshift of only 0.297. It is however, a radio-quiet quasar (RQQ) as can be demonstrated by considering *e.g.*, the ratio of the luminosity in [O III]λ5007 to the radio luminosity (Lacy, Rawlings, & Hill 1992). In contrast with other radio-quiet quasars however, E 1821+643 is located in a very rich cluster (Lacy et al. 1992) and is purported to reside in a gE host galaxy (Hutchings & Neff 1991). The full-resolution 8 GHz map

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is seen in Fig. 1. A bright unresolved core is seen with extended emission to the north-west (feature B). Features A and C are accurately diametrically opposed on either side of the core and therefore suggestive of jets; this is further supported by the alignment of features C, D and E.

The radiation field of the quasar will contribute significantly to the inverse-Compton losses in the relativistic electron population (*e.g.,* Daly 1992). Following Blandford (1990) we write the rate of energy loss per electron, P as:

$$P = \frac{\gamma^2 \sigma_{\mathrm{T}}}{\mu_{\mathrm{o}} c} \langle (\vec{E} + c\vec{\beta} \times \vec{B})^2 - (\vec{E}.\vec{\beta})^2 \rangle, \tag{1}$$

where μ_{o} is the permeability *in vacuo*, σ_{T} is the Thomson cross-section, $\vec{E}$ and $\vec{B}$ are the photon electric and magnetic fields respectively, c is the speed of light, $\vec{\beta}$ is the electron velocity in units of c, and γ is the Lorentz factor. Expanding gives:

$$P = \frac{\gamma^2 \sigma_{\mathrm{T}}}{\mu_{\mathrm{o}} c} \langle \vec{E}.\vec{E} - 2\mu_{\mathrm{o}} c\vec{\beta}.\vec{J} + c^2(\vec{\beta} \times \vec{B})^2 - (\vec{E}.\vec{\beta})^2 \rangle, \tag{2}$$

where $\vec{J}$ is the Poynting flux. Averaging over solid angle, and assuming $\gamma \gg 1$ we obtain:

$$P = \frac{4}{3} \gamma^2 \sigma_{\mathrm{T}} c U_{\mathrm{rad}}, \tag{3}$$

where U_{rad} is the energy density of the radiation field. Integrating the quasar SED (Kolman et al. 1991) over all solid angles, we find $U_{\mathrm{rad}} = 4 \times 10^{-9}/(r/\mathrm{kpc})^2\,\mathrm{J\,m^{-3}}$ where r is the distance from the nucleus. The energy density due to the radiation field of the quasar may be equated to $B^2/(2\mu_{\mathrm{o}})$ which gives an "equivalent field" of $\approx 100/(r/\mathrm{kpc})\,\mathrm{nT}$ compared with the minimum energy field of $\approx 2\,\mathrm{nT}$ derived from the radio data. Thus for distances $r < 50\,\mathrm{kpc}$ ($9''$) from the quasar, the electron ageing will be dominated by the quasar radiation field, provided the regions can see the quasar. Such high equivalent fields could therefore explain the unusually steep radio spectrum of the extended features and partial obscuration of the quasar can explain the non-axisymmetry of the spectrum around the core. Further analysis may be found in Blundell & Lacy (1995).

References

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