OPTICAL INVERSE COMPTON EMISSION IN EXTRAGALACTIC RADIO SOURCES

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In this contribution the reported detection by Saslaw, Tyson and Crane (1978) of weak optical emission in the lobes of three 3C sources - 3C 265, 3C 285 and 3C 390.3 - is reappraised in the framework of three optical emission mechanisms - synchrotron (SYN), synchrotron inverse Compton (SIC) and blackbody inverse Compton (BIC). This effort has been motivated partly by the knowledge that the contribution to the synchrotron inverse Compton emission in a radio source component is likely to become significant for very compact and bright radio components (see e.g. Okoye 1972), and partly by the recent availability of high resolution radio frequency structural data on the sources in question. Another incentive arose from the demands of a separate investigation into high energy particles interactions in radio sources (reported by Okoye and Okeke in this volume) involving very high energy protons thus making it necessary to ascertain whether such highly energetic particles exist in radio source components.

Saslaw et al (1978) had already considered the feasibility of accounting for the reported weak optical emission in the radio lobes of 3C 265, 3C 285 and 3C 390.3 through BIC. According to them, the optical emission could most likely be accounted for by the inverse Compton scattering of the '3K' microwave photons by fast radio electrons, although synchrotron emission could not be ruled out. Here we estimate the relevant contributions of each of the three emission mechanisms indicated above. The expressions for the spectral power generated in a radio source by the three emission echanisms have already been derived by a number of authors (see e.g. Felton and Morrison 1966; Okoye 1972, 1973) and will not be repeated here. Using these expressions, the optical luminosities for the radio components based on the Cambridge 5-km telescope structural data (Pooley - private communication) have been estimated and the results are given in table 1. The following inferences can be drawn about the relative importance of the optical emission mechanisms considered.

(a) The calculated integrated optical synchrotron luminosities for each of the three sources dominate over inverse Compton contributions.

(b) The calculated synchrotron luminosity is about the same as the observed optical luminosity in all the three sources observed.

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table 1
Source component optical luminosities based on various emission mechanisms.

Source components	$\log_{10}L_{SIC}$	$\log_{10}L_{BIC}$	$\log_{10}L_{SYN}$	$\log_{10}L_{OBS}$
		(luminosity in erg s-1)		
3C265				
Np A	37.7931	39.7931	44.9320	
B	38.8371	38.5846	44.0991	
	42.2045	39.5074	43.0405	
Sf	42.9350	39.7606	43.6050	
	42.4773	41.0706	44.3575	
Integrated	43.1210	41.1419	45.1003	45.0
3C285	36.0980	37.3724	41.4612	41.5
3C390.3				
Np	33.9046	36.5853	42.2485	
	36.0902	36.9571	41.1621	
Jet	35.9614	35.9621	39.3468	
C	31.0195	32.7755	42.1364	
	30.8520	32.4000	42.0872	
Sf	38.8698	38.6848	40.3468	
Integrated	38.8711	38.6970	42.6564	43.1

It seems tempting to explain the observed optical emission from the radio source lobes as due to the optical extension of the radio synchrotron radiation. This would accord with a straightforward extrapolation of the spectral index to optical frequencies. Assuming that the radio and optical photons from these source components originate from identical volumes of space, one would expect the electron energy spectrum in the emitting volumes to extend up to electron energy values sufficient to support optical synchrotron emission, if the reported weak optical emission arise from the synchrotron process. To interpret the claimed optical emission in the radio lobes correctly, it is therefore necessary to establish whether electrons with enough energies to produce the optical synchrotron spectrum actually exist in the radio source lobes or not.

For the sake of discussion we take the estimated value of $\sim 5\times10^{-5}$G as the equipartition magnetic field strength in a radio lobe of 3C285 in which case, the lifetime of the optical electrons will then be of the order of 2000 years. Thus if the optical electrons were to move away from the acceleration region at a velocity $\sim$c, they would at most move $\sim$0.7kpc during their lifetime which appears consistent with the observed scale of the optical radiation. However, if optical electrons do exist in the lobes of the extragalactic sources under consideration, then if current ideas on proton-electron energy ratios are also correct, the associated protons will have energies $\lesssim$ 2000 times those of the electrons. As indicated elsewhere (see Okeke and Okoye 1981), proton-proton interactions will lead to steady injetions of secondary electrons which will produce an optical spectrum not consistent with the extrapolated radio spectrum. It seems, therefore, that for the

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synchrotron mechanism to survive, the primary optical electrons should have radiation lifetimes much less than values fixed by equipartition magnetic field strengths. In other words, the source magnetic field strengths must be greater than equipartition values. Since equipartition magnetic field strengths are not sacrosant, there is no reason why the actual fields cannot be greater if a mechanism exists for replenishing the quickly degraded optical electrons. The problem, however, is that because the three sources under consideration are not atypical, there is then no reason why many more radio sources should not exhibit optical synchrotron emission in their lobes. This is presently not the case within optical detection limits.

As an alternative, we consider the inverse Compton mechanism. We note that the optical inverse Compton emission (SIC and BIC) is independent of the presence of optical electrons in the radio source components. Again if the actual source magnetic field strengths can differ from equipartition values, then provided the actual values are less than equipartition values, it will be possible to account for the claimed optical emission from the radio lobes of the sources under consideration by the inverse Compton mechanism. If on the other hand, equipartition conditions apply rigidly, then it is not possible to account for the claimed optical emission by either the synchrotron or inverse Compton mechanism. For this reason, it is desirable that efforts be made to confirm the claimed optical emission in the three 3C sources discussed. Because the synchrotron mechanism makes demands not only on the electron energy spectrum but also on the source magnetic field strength, the inverse Compton mechanism constraining only the source magnetic field strength, is to be preferred of the two.

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