LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Optical Positions of Radio Sources

WE present here new optical positions of sixteen radio sources with small angular diameters which are suitable as calibration sources. Optical positions for all these sources have been published previously by several authors[1–7], but those presented here are completely independent of all previous work in that they do not depend on any catalogue position or proper motions of reference stars.

A series of plates was obtained in 1967–68 with the 13-inch and 26-inch refractors and at the prime focus of the Isaac Newton telescope (INT). Each radio source position has been referred as closely as possible to the FK4 system by means of observations of some six or more BD stars which were obtained specially for this purpose with the Cooke Transit Circle during 1967.

At least two plates were obtained on each field with the 13-inch astrographic telescope, from which positions of about ten secondary reference stars with $m_{pg} \approx 13$ were derived relative to the BD stars. These secondary reference stars were used in twelve fields to derive the source positions from plates taken with the 26-inch refractor and, for the four faintest sources, to determine positions of a fainter set of reference stars, close to the source, for reduction of the prime focus Isaac Newton telescope plates. For these plates the telescope was generally diaphragmed to 80-inch aperture and for one plate to 60 inches. The final positions in Table 1 depend on plates taken with varying combinations of telescopes, according to the apparent magnitude of the source.

Table 1

Source	$\alpha_{1350\cdot 0}$ h	m	s	*S.E.* s	$\delta_{1950\cdot 0}$ °	′	″	*S.E.* ″	Chart in ref.
3C 9*	0	17	49·944	±0·008	+15	24	16·21	±0·08	8
3C 48†	1	34	49·836	0·013	+32	54	20·26	0·11	1
3C 93‡	3	40	51·562	0·011	+ 4	48	21·76	0·11	10
3C 138‡	5	18	16·508	0·012	+16	35	27·03	0·12	5
3C 147‡	5	38	43·464	0·019	+49	49	43·22	0·12	1
3C 153‡	6	5	44·384	0·018	+48	4	49·23	0·12	9
3C 186*	7	40	56·742	0·014	+38	0	31·08	0·10	5
3C 196†	8	9	59·386	0·018	+48	22	7·71	0·12	1
3C 204†	8	33	18·025	0·029	+65	24	4·44	0·12	5
3C 205†	8	35	9·942	0·023	+58	4	51·76	0·12	9
3C 249·1†	11	0	27·316	0·042	+77	15	8·62	0·09	5
3C 263†	11	37	9·296	0·028	+66	4	27·04	0·10	5
3C 277·1†	12	50	15·278	0·022	+56	50	36·72	0·12	5
3C 288·1†	13	40	29·911	0·024	+60	36	48·51	0·12	9
3C 309·1†	14	58	56·476	0·036	+71	52	11·42	0·10	9
3C 345‖	16	41	17·625	0·015	+39	54	10·99	0·10	10

* Sources measured on INT and 26-inch plates.
† Sources measured on 26-inch plates only.
‡ Sources measured on INT plates only.
‖ Sources measured on 26-inch and 13-inch plates.

The total standard error in a position includes the accidental error, ε_1, in the measured position relative to the secondary reference stars, and the systematic error, ε_2, in the determination of the system of these secondary reference stars relative to the BD stars through the astrographic plates. From intercomparison of residuals of the secondary reference stars on the astrographic plates of the same field we find ε_2 to be $\pm 0''\cdot 22$ in right ascension and $\pm 0''\cdot 12$ in declination, for one plate. The error ε_1, derived from comparisons between the positions of the sources measured on independent plates, is $\pm 0''\cdot 13$ per plate in each coordinate for both the 26-inch and the Isaac Newton telescope. The standard errors quoted in Table 1 represent the combination of ε_1 and ε_2 for each source; they do not include any contribution due to error in the derived system of the BD stars in each field, relative to FK4, which is of the order of $\pm 0''\cdot 1$.

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Predictions of Extragalactic Gamma Ray Fluxes between 1 and 100 MeV

RECENT theoretical studies have shown the need for observations of isotropic cosmic gamma radiation in the 1–100 MeV energy region. Such observations will enable us to determine the relative importance of the various processes which may produce the observed isotropic X-radiation below 1 MeV and gamma radiation above 100 MeV. The first process to be examined as a possible explanation for the radiation below 1 MeV was Compton interactions between metagalactic cosmic ray electrons and photons of the universal microwave radiation field[1–4]. Recently, we discussed additional processes which may be important in producing extragalactic gamma radiation. These processes are cosmic ray electron bremsstrahlung with intergalactic matter[5], collisions of cosmic ray nuclei with intergalactic matter which result in the production of pi-mesons[6,7], and the mutual annihilation of matter and antimatter on possible boundary regions of baryon inhomogeneity in the universe[8]. Our purpose here is to discuss some implications of these studies in distinguishing the gamma ray spectra produced by the various processes and placing upper limits on the metagalactic cosmic ray electron and nuclear fluxes. In particular, the results indicate that observational studies of isotropic gamma radiation between 1 and 100 MeV are critical for determining the dominant processes producing gamma rays in the metagalaxy and their cosmological implications.

There are similarities in the determination of gamma ray spectra from the various processes mentioned so far. Three of the processes involve collisions between high energy cosmic rays and an ambient gas with the various components listed in Table 1. The fourth process, annihilation, also involves the interaction of two components: ambient matter and ambient antimatter.

Table 1. COLLISIONAL PROCESSES PRODUCING GAMMA RAYS

Process	Primary particles	Primary ambient gas
1 Compton	Electrons	Black-body microwave photons
2 Bremsstrahlung	Electrons	Intergalactic hydrogen
3 Inelastic strong interactions	Protons	Intergalactic hydrogen nuclei