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A GAMMA-RAY FLARE IN NRAO 190

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ABSTRACT

We describe observations of the quasi-stellar object (QSO) NRAO 190 during a gamma-ray flare from 1994 August 9 to 1994 August 29. This QSO was serendipitously detected by the EGRET instrument on the *Compton Gamma Ray Observatory* in a gamma-ray flare with a luminosity at least 10 times that of its quiescent state. Optical, radio, and microwave data were obtained during or near the gamma-ray observations.

The historical behavior of this object places it in the category of bright, flat-spectrum radio sources with strong optical variability that appear to form the largest class of non-Galactic high-energy gamma-ray sources. During the gamma-ray flare the source is observed with $I(E > 100 \text{ MeV}) = 8.4 \pm 1.2 \times 10^{-7}$ photons s^{-1} cm^{-2}. A single power-law model gives a best-fit photon index of $\gamma = -1.83 \pm 0.14$.

Little evidence for major radio variability is seen during the flare or immediately afterward, although there is some increase in the 10–100 GHz flux over the next several months. There may be a slight hardening of the radio spectrum. In the optical region there are significant fluctuations on timescales of 1 day or less, although the overall optical luminosity is within the range of previous measurements. Optical observations a few weeks after the gamma-ray observations show a drop of about 60% and reduced variability. A contemporary optical spectrum shows that the source may be slightly harder than seen in a previously published spectrum. Radio monitoring of the source over the year subsequent to the flare has shown a very substantial drop in the flux at many frequencies.

Subject headings: gamma rays: observations — quasars: individual (NRAO 190)

1. INTRODUCTION

One of the most exciting observations of the *Compton Gamma Ray Observatory* (*CGRO*) has been the detection of a class of high Galactic latitude gamma-ray sources that have been identified with flat-spectrum optically variable blazars (Hartman et al. 1992; von Montigny et al. 1995, and references therein). These sources are also strongly variable in the gamma-ray region and can undergo significant changes in luminosity in periods measured in days (e.g., Kniffen et al. 1993; Hartman et al. 1993; Mattox et al. 1993, 1997a). During these "gamma-ray flares" the luminosity emitted in gamma rays dominates the total luminosity of the source unless the gamma-ray emission is much more strongly beamed than other wavelengths. Finding ways to generate this enormous luminosity of very high energy photons is now a central problem in our understanding of the behavior of blazars and active galactic nuclei (AGNs).

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Observationally, we have very little understanding of the characteristics that make a blazar detectable. A central question is whether this flare phenomenon is inherent in all blazars and we are seeing a selection of them, or whether only certain types of blazars have inherent gamma-ray emission (e.g., Dermer 1995).

To assist in the understanding of these objects, contemporaneous observations in other wavelength regimes are needed to complement the gamma-ray observations before, during, and after the flare. Unfortunately, the number of flares that have been seen is still relatively small, and contemporaneous observations at other wavelengths are often difficult to obtain. Collaborations (e.g., Maraschi et al. 1994) have been set up to monitor sources scheduled to be observed by EGRET. Unfortunately, most potential targets fail to cooperate and are not detected in a flare state.

During observations centered in EGRET viewing period (VP) 337 from 1994 August 8 to August 29, the EGRET instrument detected a strong serendipitous gamma-ray source near Galactic coordinates $l = 197\overset{\circ}{.}0$, $b = -29\overset{\circ}{.}5$. The only known nearby object fitting the typical criteria of EGRET sources was NRAO 190, which was on the preliminary 95% confidence contour. The a priori likelihood of such a coincidence was at best a few percent, so the gamma-ray emission was identified with this source.

The community was notified by an IAU telegram (McGlynn et al. 1994) of the desirability of immediate observations. Despite the short notice, several contemporaneous or near-contemporaneous measurements were made of the object at radio, microwave, and optical wavelengths. This paper reports on these observations. The next section (§ 2) discusses the EGRET detection, the identification with NRAO 190, and observations in other wave bands. The final section (§ 3) discusses the implications of these observations.

2. OBSERVATIONS

During VP 337 from 1994 August 8 to August 29, the EGRET instrument of the *CGRO* was pointed at the field centered on $l = 203\overset{\circ}{.}8$, $b = -15\overset{\circ}{.}15$. The EGRET instrument has a very large field of view in its normal mode, covering approximately 0.5 sr of the sky. The spatial resolution of the instrument depends strongly on the energy of the incident radiation and is of order a few degrees. Detailed characteristics of the EGRET instrument are described elsewhere (Hughes et al. 1980; Kanbach et al. 1988).

2.1. *The EGRET Observations*

The analysis of the VP 337 data detected a source with a maximum likelihood location of $l = 197\overset{\circ}{.}24$, $b = -28\overset{\circ}{.}91$ at approximately the 10 σ level. The 95% confidence contours for the source were fitted by an ellipse with axes of $38' \times 30'$ and a position angle of 69°. The ellipse centroid was at $l = 197\overset{\circ}{.}38$, $b = 28\overset{\circ}{.}99$. The source flux ($8.4 \pm 1.2 \times 10^{-7}$ photons s^{-1} cm^{-2}) during the flare is 10 times the upper limits set during the EGRET all-sky survey (Fichtel et al. 1994). A power-law fit to the spectrum gives a spectral index of 1.83 ± 0.14. There is some slight evidence for a cutoff in the emission at low energies (< 200 MeV). The dependence at higher energies would be somewhat steeper if a roll-off were included, but the data do not demand this.

Subsequent analysis of data from VPs 321.1 and 321.5 (1994 February 8 to 17) yielded a 3.3 σ detection of a source coincident with that seen in VP 337. In these observations the source was approximately 30° from the center of the field of view. The estimated flux for this detection is $4.6 \pm 1.9 \times 10^{-7}$ photons s^{-1} cm^{-2} for $E > 100$ MeV. Combining the two detections gives a maximum likelihood location of $l = 197\overset{\circ}{.}53$, $b = -28\overset{\circ}{.}55$. The 95% confidence contours can be fitted with an ellipse with dimensions of $36' \times 26'$.

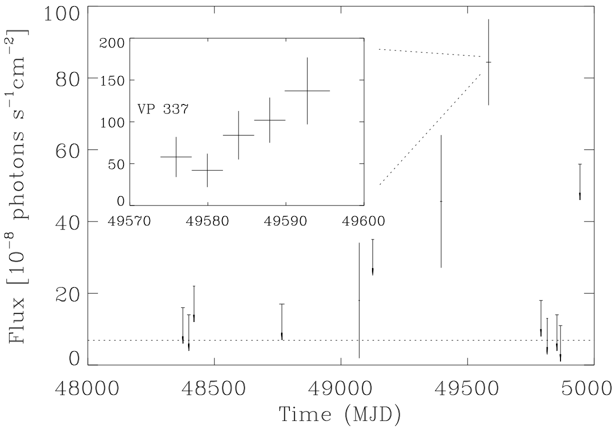

FIG. 1.—EGRET observations and upper limits for the NRAO 190 region.

No other significant detection of the source is made in any other period during which EGRET observed this region, although there is a 1 σ "detection" in VP 213. Given the number of observations, this low-significance detection has been treated as a random fluctuation. Combining all data except the two significant detections, we find an upper limit for the persistent flux of 6.9×10^{-8} photons s^{-1} cm^{-2}.

The brightness of the gamma-ray source shows indications of a substantial increase in the second and third weeks of the 1994 August observation relative to the first week. However, the data are incompatible with constant flux at only about the 2 σ level. The fluxes, or upper limits on the flux, for all EGRET viewing periods where NRAO 190 would be visible are displayed in Figure 1 and tabulated in Table 1.

2.2. *Identification of the Source*

The preliminary source position was close to the flat-spectrum optically variable radio source NRAO 190

TABLE 1

EGRET OBSERVATIONS OF THE NRAO 190 REGION

Viewing Period(s)	Date	MJD	Flux (10^{-8} photons s^{-1} cm^{-2})
0.2–0.5	1991 Apr 22	48368	<16
10	1991 May 16	48392	<14
2.1	1991 Jun 08	48415	<22
29	1992 May 14	48756	<17
213	1993 Mar 23	49069	18.0 ± 16.1[a]
221	1993 May 13	49120	<35
321.1–321.5	1994 Feb 08	49391	45.6 ± 18.5
337	1994 Aug 09	49573	84.4 ± 12.0
413	1995 Mar 07	49783	<18
419.1	1995 Apr 04	49811	<13
419.5	1995 May 09	49846	<14
420	1995 May 23	49860	<11
426	1995 Aug 08	49937	<56

[a] Upper limit of less than 53.

(0440−003) at $l = 197\overset{\circ}{.}20$, $b = -28\overset{\circ}{.}46$. This object is typical of many of the high Galactic latitude EGRET sources with strong, core-dominated, flat-spectrum radio emission, significant optical and radio polarization, and strong optical variability. An identification was made with preliminary data prior to the end of the observation.

Figure 2 illustrates the likelihood confidence contours for the position of the source assuming only statistical errors. Data are included both from the 1994 August and 1994 February detections. The systematic errors may substantially increase the sizes of these contours. The final position remains consistent with the identification with NRAO 190, lying between the 50% and 68% confidence levels. Without the addition of the February data, NRAO 190 would lie just within the 95% confidence contour.

A Bayesian analysis of the likelihood that NRAO 190 is the proper identification—using both the August and February data—gives an a posteriori likelihood of 91% that the identification is correct using only information on the flux and hardness of candidate sources (Mattox et al. 1997b). This analysis uses a few unequivocally identified sources, e.g., 3C 279, to bootstrap an analysis of the probability that sources being identified as blazars are correct. Note that the identification with NRAO 190 uses neither its known variability in optical and radio, nor the fact that the source has a strong unresolved component in VLBI observations (Preston et al. 1985), nor the fact that the source is now detected to have superluminal motion (see § 2.3). Since this behavior of NRAO 190 so clearly mimics the paradigm of EGRET detections, our confidence in the identification is substantially higher than the simple result from Bayesian analysis.

2.3. *Radio, Microwave, and Optical Observations*

Observations were taken after the identification of the flare to look for activity that might be associated with the gamma-ray event. Radio and microwave observations are summarized in Table 2, and the results of optical monitoring are given in Table 3.

NRAO 190 was observed at wavelengths 2.0, 1.3, and 1.1 mm (150–270 GHz) on 1994 September 6 and 9 with the UKT14 bolometer (Duncan et al. 1990) on the James Clerk Maxwell Telescope (JCMT), operated by the Royal Observatories on behalf of the Particle Physics and Astronomy Research Council of the United Kingdom, the Netherlands Organization for Scientific Research, and the National Research Council of Canada. These data were analyzed in a standard manner (see, e.g., Stevens et al. 1994).

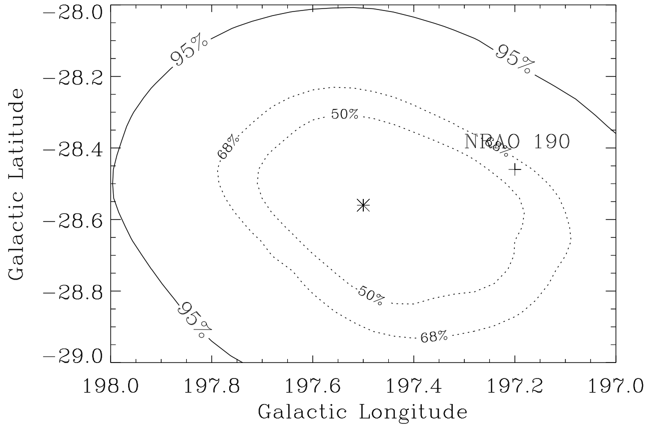

FIG. 2.—Likelihood map for the combined EGRET observations

Data were taken at 4.8, 8.0, and 14.5 GHz at the University of Michigan Radio Astronomy Observatory starting shortly after the flare. This source has been monitored at UMRAO for many years, with one observation dating back to 1968, but no observations had been made for several years preceding the flare. UMRAO continued to monitor the source through 1995. Figure 3 includes both historical data and more recent observations. After the flare the source is relatively bright and shows considerable variability, but this seems to be consistent with its historical behavior.

Data were also taken at the MPI 100 m telescope at Effelsberg (Reich et al. 1993), the Metsähovi Radio Observatory, and the Swedish-ESO Submillimetre Telescope (SEST). The Metsähovi 14 m radio telescope has been used for quasar research in a joint research program of the Helsinki University of Technology and the Turku University since 1980. The majority of the telescope's observing time is dedicated to monitoring quasars and other active galactic nuclei at 22, 37, and 90 GHz. SEST is a 15 m radio telescope built in 1987, which operates in the frequency range 70–365 GHz.

In Figure 4, data from all frequencies 4.8–270 GHz have been plotted as a function of time. Coverage is irregular at all frequencies. The legend at the top of the plot includes the typical error bars for each frequency. Frequencies for which we have only a single point are not plotted.

Figures 5 and 6 plot the energy output as a function of frequency. In the radio regime the error bars are typically smaller than the points. In addition to the data taken for this event, historical information retrieved from the NASA/IPAC Extragalactic Database (NED) (see Helou et al. 1991) database is included. Additional archival data not described in NED are included in this figure and given in Table 4.

Figure 5 shows the entire range of data from radio through gamma rays, while Figure 6 details the radio regime, in which there are many historical and contemporary observations. Figure 5 also shows the best-fit gamma-ray power-law spectrum as a dotted line. A dotted region in the optical indicates the historical range of the source brightness as seen by Smith et al. (1993). The circles in this region indicate the range in the contemporary measured optical brightnesses. Upper limits in the far-infrared are inferred from the lack of detection in the *IRAS* Point Source and Faint Source Catalogs.

Preliminary analysis of VLBI observations taken after the gamma-ray flare show evidence of superluminal motion of approximately 13c (for $H_0 = 65, q_0 = 0$). (A. P. Marscher, 1996, private communication). The observations do not have sufficient resolution to detect an event corresponding to the gamma-ray flare seen by EGRET—the superluminal motion seems to correspond to a blob emitted approximately 1 yr earlier. Continued monitoring is underway.

Optical monitoring of the source was done at Sternwarte, Heidelberg (Wagner et al. 1995a), where a program is underway to look at potential sources simultaneously with EGRET. Thus the source had been monitored prior to the announcement of the EGRET detection. Additional observations were taken within a few days of the announcement of the detection. The results of the optical monitoring are shown in Figure 7, which gives the relative flux of the source as a function of time.

TABLE 2

CONTEMPORARY RADIO OBSERVATIONS

Date	MJD	Frequency (GHz)	Flux (Jy)	Observatory
1995 Feb 07	49755	2.695	1.87 ± 0.08	MPIfR
1994 Sep 09.55	49604.55	4.8	1.76 ± 0.05	UMRAO
1994 Nov 02.32......	49658.32	4.8	1.73 ± 0.05	UMRAO
1994 Nov 04.32......	49660.32	4.8	1.87 ± 0.04	UMRAO
1995 Feb 07	49755	4.75	1.77 ± 0.06	MPIfR
1994 Sep 01.48	49596.48	8.0	1.44 ± 0.08	UMRAO
1994 Nov 14.29......	49670.29	8.0	1.75 ± 0.07	UMRAO
1994 Aug 29	49593	8.6	1.60 ± 0.10	MPIfR
1995 Feb 07	49755	8.6	1.63 ± 0.10	MPIfR
1994 Oct 14..........	49639	10.45	1.42 ± 0.08	MPIfR
1995 Jun 23..........	49891	10.45	1.27 ± 0.11	MPIfR
1994 Aug 27.52......	49591.52	14.5	1.49 ± 0.03	UMRAO
1994 Dec 16	49702	22	1.44 ± 0.09	Metsähovi
1995 Jan 06..........	49723	22	1.47 ± 0.06	Metsähovi
1995 Feb 05	49753	22	1.54 ± 0.08	Metsähovi
1995 Apr 06	49813	22	1.13 ± 0.14	Metsähovi
1995 Apr 08	49815	22	1.19 ± 0.14	Metsähovi
1995 Apr 14	49821	22	1.17 ± 0.09	Metsähovi
1995 Apr 24	49831	22	1.21 ± 0.13	Metsähovi
1995 Apr 28	49835	22	1.17 ± 0.08	Metsähovi
1995 Jun 21..........	49889	22	1.16 ± 0.10	Metsähovi
1995 Aug 03	49932	22	0.93 ± 0.08	Metsähovi
1995 Jul 11...........	49909	32	0.95 ± 0.10	MPIfR
1994 Dec 22	49708	37	1.27 ± 0.09	Metsähovi
1995 Jan 13..........	49730	37	1.24 ± 0.06	Metsähovi
1995 Feb 08	49756	37	1.30 ± 0.07	Metsähovi
1995 Apr 13	49820	37	1.08 ± 0.09	Metsähovi
1995 Apr 23	49830	37	0.98 ± 0.08	Metsähovi
1995 Jul 12...........	49910	37	0.90 ± 0.07	Metsähovi
1995 Aug 03	49932	37	0.66 ± 0.08	Metsähovi
1994 Oct 01..........	49626	90	0.84 ± 0.061	SEST
1994 Dec 13	49699	90	1.11 ± 0.062	SEST
1995 Feb 26	49774	90	0.75 ± 0.047	SEST
1995 Apr 01	49808	90	0.76 ± 0.064	SEST
1994 Sep 06..........	49601	150	0.77 ± 0.06	JCMT
1994 Sep 09..........	49604	150	0.67 ± 0.13	JCMT
1994 Sep 06..........	49601	230	0.52 ± 0.04	JCMT
1994 Dec 12	49698	230	0.61 ± 0.049	SEST
1995 Apr 01	49808	230	0.31 ± 0.065	SEST
1994 Sep 06..........	49601	270	0.52 ± 0.04	JCMT
1994 Sep 09..........	49604	270	0.61 ± 0.06	JCMT

An 1800 s optical spectrum was taken with the Kast spectrograph (Miller & Stone 1993) on the 3 m Shane reflector at the Lick Observatory on 1994 September 3 (JD = 2,449,598.92), a few days after the end of the EGRET observation. The spectrum from this observation is shown in Figure 8. Other than a strong emission line consistent with Mg II, few features are seen in the spectrum. The atmospheric seeing during the observation was poor ($2''$–$3''$) and the absolute calibration of the data is not reliable, although we believe the relative flux calibration is correct.

TABLE 3

OPTICAL MONITORING OF NRAO 190

Date	MJD	Flux (1.0 for $m_B = 17.8$)
1994 Aug 10.16......	49574.164	1.186 ± 0.011
1994 Aug 16.11......	49580.114	0.973 ± 0.011
1994 Aug 17.17......	49581.167	1.352 ± 0.011
1994 Aug 18.13......	49582.126	1.524 ± 0.011
1994 Aug 19.11......	49583.113	1.385 ± 0.011
1994 Sep 02.69	49597.692	0.878 ± 0.011
1994 Sep 04.61	49599.614	0.733 ± 0.011
1994 Sep 07.67	49602.668	0.842 ± 0.011
1994 Sep 07.67	49602.670	0.844 ± 0.011
1994 Sep 09.66	49604.660	0.831 ± 0.011
1994 Sep 11.68	49606.684	0.940 ± 0.011

2.4. *Historical Observations*

NRAO 190 ($z = 0.844$), a strong, flat-spectrum radio source near the equator, is visible to both northern and southern observatories and has been included in many surveys. A total of 34 measurements available through NED are included in Figures 5 and 6.

This source is easily detected to 270 GHz and exhibits variability at virtually all wavelengths. VLBI observations (Preston et al. 1985) of the source indicate that it is core-dominated, with 40% of its flux arising from the unresolved core. VLA observations at 20 cm (Price et al. 1993) show a single compact object.

A long-term optical study of QSOs undertaken by Smith et al. (1993) and Smith (1995) follows the optical behavior of NRAO 190 from 1970 through 1992. The source shows strong fluctuations on all timescales and had a "quiescent" photographic magnitude of ~18.5–19.0 mag during 1975–1985. Since that time the source has significantly brightened, with a minimum brightness at $m_P \approx 18.0$ mag. The

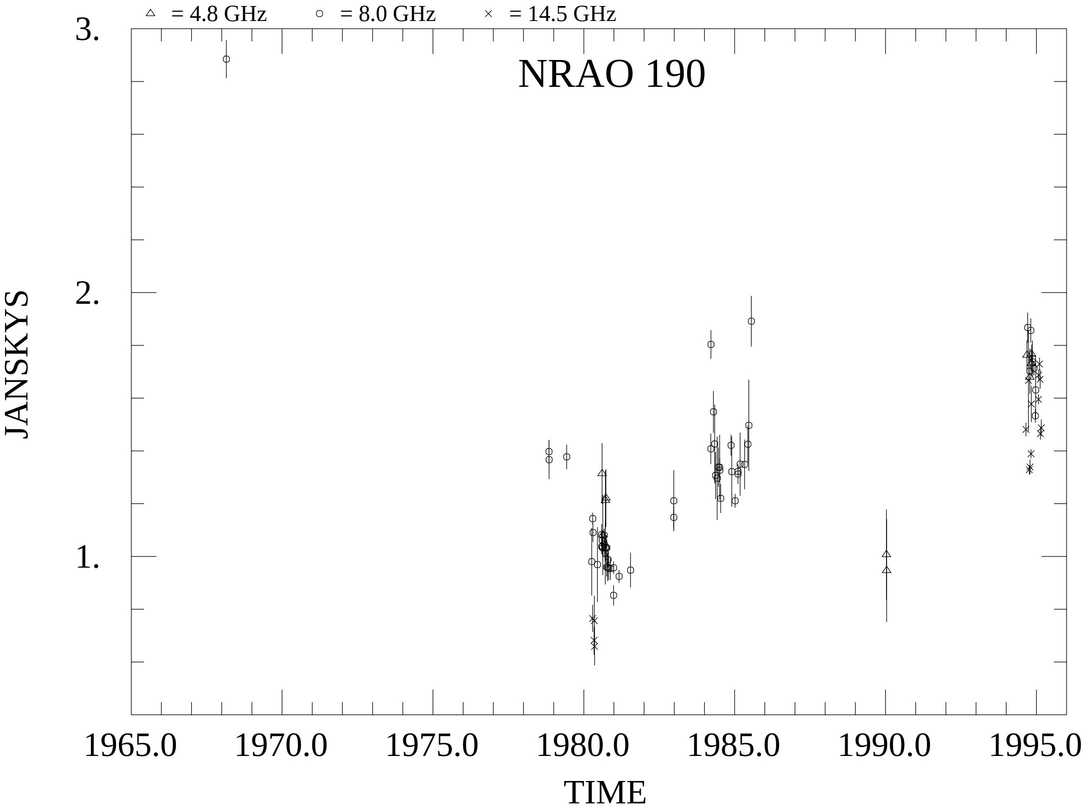

FIG. 3.—University of Michigan Radio Astronomy Observatory monitoring of NRAO 190

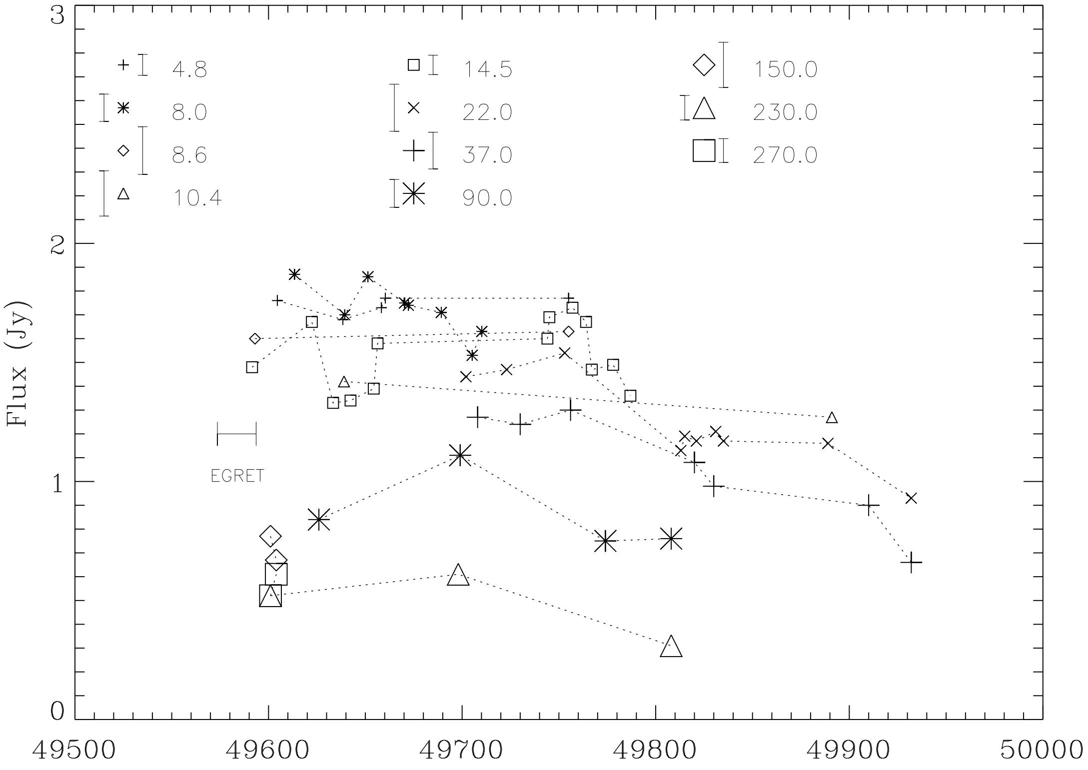

FIG. 4.—Radio, microwave, and millimeter monitoring after the gamma-ray flare. Symbols are for the frequency (in GHz) in the legend at the top of the figure. The average error bar for that frequency is given next to the symbol. The duration of the EGRET observation is indicated by the horizontal line.

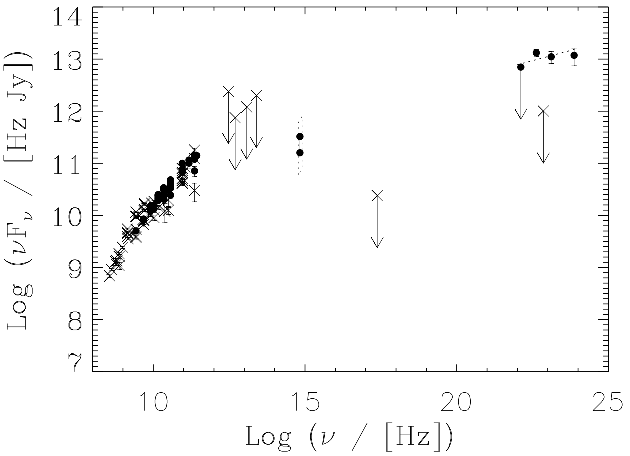

FIG. 5.—Plot of νF_ν for NRAO 190. Filled circles indicate contemporaneous observations, while crosses indicate older observations obtained from NED or from Table 4. See discussion in the text for other features.

last measurements available from the Smith et al. survey are $m_P = 17.6$ mag in early 1992. Since we do not have optical magnitudes from immediately before the flare (and we do not know exactly when the flare started), it is difficult to assert confidently that there was not a corresponding optical flare. However, the measured magnitudes during the gamma-ray event seem typical of the Smith et al. range (see Fig. 5), indicating that NRAO 190 was not in an unusually high optical state.

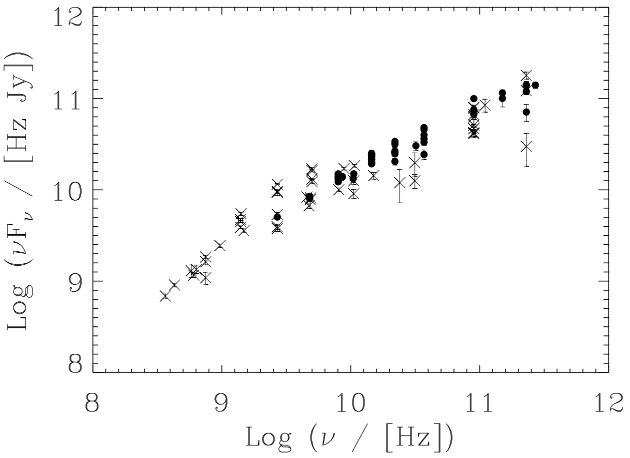

FIG. 6.—Radio spectrum of NRAO 190. Symbols are the same as in Fig. 4.

TABLE 4

PREVIOUS RADIO OBSERVATIONS

Date	MJD	Frequency (GHz)	Flux (Jy)	Observatory
1992 May 16......	48758	2.695	1.40 ± 0.06	MPIfR
1992 Nov 25......	48951	2.695	1.46 ± 0.08	MPIfR
1992 Nov 25......	48951	4.750	1.40 ± 0.06	MPIfR
1992 May 16......	48758	10.55	0.86 ± 0.06	MPIfR
1992 Nov 25......	48951	10.55	1.19 ± 0.11	MPIfR
1988 Aug 21......	47394	90	0.46 ± 0.040	SEST
1988 Dec 01......	47496	90	0.57 ± 0.080	SEST
1989 Feb 01......	47558	90	0.74 ± 0.080	SEST
1991 Oct 12......	48541	90	0.89 ± 0.050	SEST
1991 Oct 24......	48553	90	0.88 ± 0.060	SEST
1991 Dec 11......	48601	90	0.47 ± 0.040	SEST
1991 Dec 12......	48602	90	0.52 ± 0.050	SEST
1991 Dec 18......	48608	90	0.46 ± 0.040	SEST
1991 Dec 25......	48615	90	0.52 ± 0.060	SEST
1987 Oct 27......	47095	110	0.77 ± 0.124	SEST
1991 Aug 29......	48497	230	0.53 ± 0.050	SEST
1992 Aug 25......	48859	230	0.78 ± 0.069	SEST
1993 Feb 26......	49044	230	0.13 ± 0.051	SEST

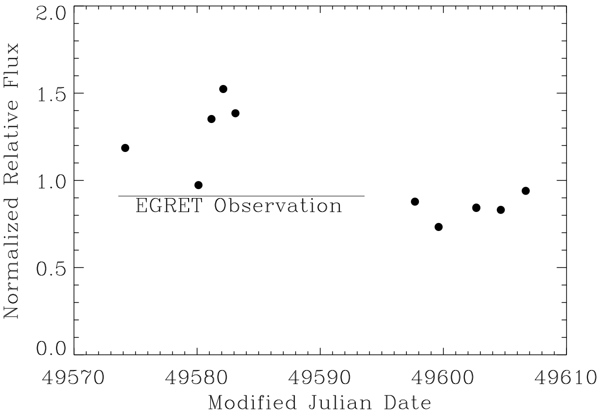

FIG. 7.—Optical variations of NRAO 190. The duration of the EGRET observation is indicated by the horizontal line.

NRAO 190 has not been detected as an X-ray source. *Einstein* upper limits on the flux of the source are less than 8×10^{-13} ergs cm^{-2} s^{-1} (Wilkes et al. 1994). The region has not been observed by *ROSAT* in any data made public before 1996 March.

3. DISCUSSION

NRAO 190 appears to have the typical characteristics of an EGRET high Galactic latitude source. Historically, it shows strong optical variability and some optical polarization. At radio wavelengths the source is variable and core-dominated, with measurable if not strong polarization. It is a strong (1 Jy) source up to millimeter wavelengths. It is not a strong X-ray source, but X-ray properties do not seem to be a good predictor of gamma-ray blazars.

The 3.3 σ detection of NRAO 190 6 months prior to the flare seen in August has interesting implications. The data are consistent with a nearly constant flux over the 6 months. However, given the temporal variations seen in other gamma-ray sources, we may just as easily be seeing two separate flaring events. Either gamma-ray flares can be quite long-lived, or the recurrence interval between flares in a given source can be as short as a few months.

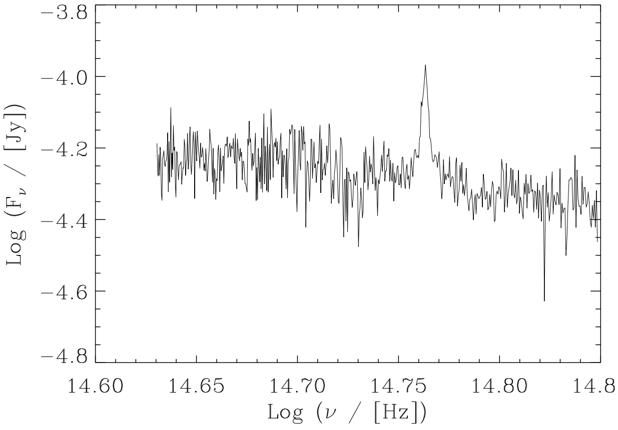

FIG. 8.—Optical spectrum for NRAO 190 on 1994 September 4

3.1. *The Gamma-Ray Flux*

Using the measured redshift of $z = 0.844$ and assuming a flat $\Omega = 1$ cosmology, we find that the isotropic luminosity of the gamma-ray source is $8 \times 10^{47}\ h^{-2}$ ergs s^{-1} for the energy range corresponding to the measured EGRET flux in the 100–10,000 MeV region where $h \equiv H_0/(100\ \mathrm{km\ s^{-1}})$. The classical Eddington limit for a $10^{10}\ M_\odot$ black hole is approximately 10^{48} ergs s^{-1}. However, it has been noted by Dermer & Gehrels (1995a, 1995b; see also Mattox et al. 1997a) that this limit does not apply in the gamma-ray regime where the Klein-Nishina Compton cross section is much smaller than the Thompson cross section. Using the Klein-Nishina cross section, the lower limit for the mass of a central black hole is about $2 \times 10^7\ h^{-2}\ M_\odot$. This is consistent with the expected mass of central-engine black holes; however, most models of the emission from these sources have strong relativistic beaming of the radiation (e.g., Schönfelder 1994) so that the actual luminosity of the source may be substantially reduced.

Even if the gamma-ray fluxes shown in Figure 5 are reduced by 2 orders of magnitude, the total energy in gamma radiation will be comparable to the peaks in the radio/microwave and in the optical regions (which may themselves be substantially nonisotropic). The energy output could be roughly constant from 10^{12} to 10^{22} Hz except for the upper limits in the X-ray regime. Unless the beaming fraction is remarkably small, the energy output in gamma rays is a major fraction of the total luminosity and may well dominate energy losses from the source during the flare.

3.2. *Radio and Microwave Observations*

During and after the gamma-ray flare there is some indication of a hardening of the radio and microwave spectrum around 10–100 GHz (see Fig. 6). Figure 4 shows no strong evidence for flaring in the few weeks after the burst, with the caveat that the temporal coverage is not dense.

Observations in the 14.5–230 GHz regime indicate that the source brightened approximately 100 days after the flare and declined thereafter, quite substantially at some wavelengths. This is consistent with the previous observations (Reich et al. 1993; Valtaoja & Teräsranta 1995), which show a tendency for gamma-ray flares to be during periods of rising emission at 10–100 GHz, with peaks up to several months later.

However, it is dangerous to assume that these behaviors are simply associated with the flare observed in August. NED observations and the data in Table 4 show similar variations. Since this source apparently has recurrent flares with intervals of a few months, the radio variations could be independent of the gamma-ray emission, or associated with another unobserved gamma-ray event. The radio variations we see are comparable in magnitude to the historical fluctuations.

3.3. *Optical Observations*

NRAO 190 exhibited strong day-to-day optical variations in the data taken contemporaneously with the EGRET observation, including variations of as much as 40% in a single day. Data taken a few weeks later tend to show a lessening of the variability of the object and a general reduction in brightness with a maximum fluctuation of 20% over 2 days. However, the total brightness of the source is well within the historical limits. Several other sources have shown similar behavior (e.g., Wagner et al. 1995b; Wagner 1996; von Linde et al. 1993). In other flares it appears that the mechanism producing the gamma-ray flare influences strongly the optical variability of the source, even when the luminosity is not atypically high.

We have no data on the gamma-ray luminosity of NRAO 190 during its largest optical excursions (see, e.g., the 1990 peak in Smith et al. 1993); it is possible that these other optical peaks corresponded to significant gamma-ray activity as well. Similarly, we do not have gamma-ray observations after 1994 August, when the optical brightness and variability seem to have declined somewhat. Our data indicate that the flux in the later weeks of the 1994 August observation was at least as high as that during the first week.

Our optical spectrum of NRAO 190 does show a steeper slope than an earlier published spectrum (Jackson & Browne 1991). Both spectra show prominent Mg II emission, but otherwise there are no strong spectral features. Thus, while the gamma-ray flare may affect the energetics of the optical emission, it does not seem to have changed the state of the medium producing optical emission in any obvious way.

Overall, as with many gamma-ray flares, the observations of NRAO 190 are less revealing than we would like. The lack of intensive simultaneous coverage at multiple wavelengths and the fact that the source's typical behavior includes substantial activity make it difficult to relate the behavior at other wavelengths to the gamma-ray event. Indeed, it may be a characteristic of gamma-ray–bright blazars that they have greater variability at other wavelengths (Aller, Aller, & Hughes 1996) than randomly selected blazars. Our observations do suggest that high optical or radio luminosity need not correlate with flares. There is some suggestion of changes in the spectrum in the optical and radio from 10–100 GHz. Our data are consistent with observations that the optical variability is enhanced during a flare, but lend little independent support since we do not know when the gamma-ray flare began or ended.

Relatively few gamma-ray flares have been both observed well with the EGRET instrument and carefully monitored at other wavelengths. As more data from these events become available we may hope that the observational signature of the events will become more distinct and lead to a more unambiguous understanding of the astrophysics of these AGNs.

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