OSSE OBSERVATIONS OF ACTIVE GALAXIES AND QUASARS

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ABSTRACT

We present a summary of OSSE observations of galaxies and quasars that have been carried out during the Phase 1 all-sky survey by the *Compton* Observatory. The OSSE instrument has detected continuum emission from several Seyfert galaxies and quasars. Seyfert 1 galaxies make up the majority of the detections, typically at energies below 300 keV, with the measured spectra generally compatible with power-law continuum models with photon spectral indices around −2, or with thermal emission models with temperatures around 50 keV. The quasars generally have harder spectral indices than the Seyfert galaxies.

With the exception of Centaurus A and NGC 4151, there is little evidence of significant flux variability in the OSSE data sets for most of the Seyfert galaxies observed. In some cases, the OSSE detections are at flux levels significantly below those reported for previous observations.

While the analysis of the complete set of Phase 1 OSSE observations of active galaxies is still in progress, the OSSE data will clearly provide a major new database for the examination and testing of models of high-energy emission from active galactic nuclei.

INTRODUCTION

The OSSE instrument provides an excellent capability for hard X-ray and gamma-ray observations of active galaxies and quasars. Detailed descriptions of the capabilities and performance of the OSSE instrument are given elsewhere (Cameron *et al.*, 1992, Johnson *et al.*, 1993). OSSE typically observes 2 separate targets during an observation period, switching to a secondary target during the fraction of each orbit when the primary target is occulted by the Earth. The four

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OSSE detectors are capable of observing a target over 90 degrees of detector positioning. Detector occultation occurs outside this range of detector position angles, though two unocculted detectors remain available for observations. Typical observations are of 2 or 3 weeks duration, although some observations may span only a few days, dictated by events such as targets of opportunity. The actual integration time that is useful for analysis on an object in any observation period is a function of several parameters, including the number of detectors used in the observation, and the relative priority of time allocation for the object during the observation period.

During the 18-month all-sky survey carried out in the first phase of the *Compton* Observatory mission, the OSSE instrument was able to perform pointed observations for more than 30 active galaxies and quasars. This paper presents a summary of these OSSE observations of galaxies and quasars, including indication of which objects have been detected in the analysis carried out to date. Several objects were observed more than once, which will provide an opportunity for examining source flux variability on timescales ranging from days to months.

THE OBSERVATIONS

A complete list of Phase 1 OSSE observations of galaxies and quasars is given in Table 1. Thirty-six objects are listed, with twenty-five Seyfert galaxies making up the majority of the objects. Detailed analysis has been carried out for about half of the objects. Work continues on refining the understanding of systematic errors in the datasets, which will allow final evaluation of model parameters.

Observations are listed only for those times when the object was the specific target for the observation. Observing periods when an object was in a background field or at low sensitivity in the field of another target are not included. The table gives the following information for each object: source name; position in J2000 equatorial coordinates; object type; redshift, or heliocentric velocity in km s^{-1}; the time interval(s) over which the object was observed; the gain of the OSSE instrument during the observation ($\times 1$ gain provides data up to 10 MeV, $\times 2$ gain provides data up to 5 MeV); the number of detectors used for the observation; and an indication of the detection of the object in OSSE data that has been analyzed to date. Object types, redshifts and heliocentric velocities were generally obtained from the NASA/IPAC Extragalactic Database.

Analysis has not yet been completed for all of the observations shown. However, more than 50% of the objects analyzed to date have been detected by OSSE. Marginal or doubtful detections are indicated in the table, for those objects with detections of between approximately 2σ and 5σ significance between 60 keV and 500 keV.

Analysis of OSSE observations of the starburst galaxies M 82 and NGC 253 are presented in these proceedings (The *et al.*, 1993, Bhattacharya *et al.*, 1993). For the Seyfert galaxies, only one Seyfert 2 has been detected, this being the nearby galaxy Centaurus A. The other Seyfert 1 galaxies that have been detected generally show weak emission at hard x-ray energies, except for NGC 4151, which has a stronger flux than the other Seyferts by virtue of its proximity. Detailed analysis of the spectrum of NGC 4151 is described by Maisack *et al.* (1993). The detection rate for Seyfert 1 galaxies, including marginal detections, is close to 100%, indicating a promising class of objects for study with OSSE at hard x-ray energies. The quasars 3C 273 and 3C 279 show power-law spectra, with harder emission than a typical Seyfert 1 galaxy. Details of these detections will be given elsewhere as the final analysis is completed for each object.

Variability has been detected in three objects: Centaurus A (Kinzer *et al.*, 1993); NGC 4151, where a flux difference of $\sim 25\%$ was measured for the two observation epochs; and 3C 111, where the source was detected in its first observation by OSSE, but not in the second observation. Background subtraction systematics are still being investigated in the case of 3C 111.

SUMMARY

With the ability of the OSSE instrument to carry out high-sensitivity pointed observations of active galaxies at hard X-ray energies, and the detection rate demonstrated by the current analysis of OSSE data collected during Phase 1 observations, the OSSE instrument should provide a valuable dataset of high-energy emission measurements from extragalactic objects, which will refine the understanding of energetic processes in the nuclei of galaxies.

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Table 1. Galaxies and Quasars Observed by OSSE

Object	RA	Dec	Type	$z(V_{hel})$	Obs. Dates	Gain	#Detectors	Detected?
MRK 335	00 06 19.4	+20 12 11	Sy 1	(7735)	92/114 – 92/119	×1	4+2	
					92/128 – 92/135	×1	4+2	
					92/233 – 92/240	×2	2	
NGC 253	00 47 33.2	−25 17 19	SAB(s)c	(251)	91/248 – 91/255	×1	4	
					91/311 – 91/318	×1	4	
					91/346 – 91/361	×1	2	
					92/037 – 92/051	×2	2	
					92/079 – 92/093	×1	4	
NGC 1068	02 42 40.1	−00 00 48	Sy 2	(1137)	92/051 – 92/065	×1	4+2	N
NGC 1275	03 19 48.1	+41 30 42	Sy 2	(5260)	91/332 – 91/346	×1/×2	4	N
3C 111	04 18 21.6	+38 01 37	Sy 1	0.049	91/179 – 91/193	×1	4	Y
					92/135 – 92/156	×2	2	N
3C 120	04 33 11.0	+05 21 16	Sy 1	0.033	92/135 – 92/156	×2	2	Y?
					92/156 – 92/198	×1	4	Y?
PKS 0528+134	05 30 56.4	+13 31 55	QSO	2.06	92/282 – 92/289	×1	2	N?
					92/308 – 92/322	×1	2	N?
PKS 0548−322	05 50 41.8	−32 16 11	BL Lac	0.069	92/163 – 92/177	×1	2	
MCG +8−11−11	05 54 55.2	+46 26 25	Sy 1	(6141)	92/163 – 92/177	×1	4	Y
QSO 0736+016	07 39 18.0	+01 37 05	QSO	0.191	91/167 – 91/179	×1	4	N
QSO 0834−201	08 36 39.1	−20 16 59	QSO	1.715	92/282 – 92/289	×1	2	
					92/308 – 92/322	×1	2	
MCG +5−23−16	09 34 15.4	+27 19 38	Sy 2	(3202)	92/225 – 92/261	×2	2	
NGC 2992	09 45 41.9	−14 19 35	Sy 2	(2314)	92/156 – 92/163	×1	4	
					92/184 – 92/198	×1	4	
MCG −5−23−16	09 47 40.1	−30 56 55	Sy 2	(2498)	92/219 – 92/225	×1	4	
					92/240 – 92/245	×1	4	
M 82	09 55 53.9	+69 40 57	I0	(203)	91/221 – 91/227	×1	4	
					92/010 – 92/023	×1	4	
MRK 421	11 04 27.3	+38 12 32	BL Lac	(9234)	91/193 – 91/207	×1	2	N
					91/207 – 91/220	×2	2	N
					91/255 – 91/262	×2	4	N
NGC 3783	11 39 01.7	−37 44 19	Sy 1	(3033)	92/177 – 92/184	×1	4	Y?
NGC 4151	12 10 32.4	+39 24 20	Sy 1	(995)	91/179 – 91/193	×1	4	Y
					92/093 – 92/107	×2	2	Y

Table 1. Galaxies and Quasars Observed by OSSE (*cont.*)

Object	RA	Dec	Type	$z(V_{hel})$	Obs. Dates	Gain	#Detectors	Detected?
NGC 4388	12 25 46.6	+12 39 41	Sy 2	(2517)	92/261 – 92/282	×1	3	
3C 273	12 29 06.6	+02 03 09	QSO	0.158	91/166 – 91/179	×1	4	Y
					91/234 – 91/248	×1	4	Y
					91/276 – 91/290	×1	4	Y
					92/225 – 92/228	×2	2	Y
					92/251 – 92/257	×2	2	Y
M 87	12 30 49.4	+12 23 28	Sy	(1282)	92/261 – 92/282	×1	3	
NGC 4593	12 39 39.3	−05 20 39	Sy 1.9	(2492)	92/228 – 92/233	×2	2	N
					92/257 – 92/261	×2	2	N
3C 279	12 56 11.1	−05 47 22	QSO	0.538	91/262 – 91/276	×1	2	Y
					92/245 – 92/251	×2	2	Y
Centaurus A	13 25 28.9	−43 00 59	S0 pec, Sy 2	(562)	91/290 – 91/304	×1	4	Y
					92/303 – 92/308	×2	4	Y
MCG −6−30−15	13 35 50.8	−34 17 29	Sy 1	(2329)	92/282 – 92/289	×1	4	
					92/308 – 92/322	×1	4	
IC 4329A	13 49 18.3	−30 18 34	Sy 1	(4813)	92/282 – 92/289	×1	4	Y
					92/308 – 92/322	×1	4	Y
MRK 279	13 53 01.7	+69 18 29	Sy 1	(9144)	92/065 – 92/079	×1	4	Y
NGC 5548	14 17 59.4	+25 08 13	Sy 1.2	(5149)	91/227 – 91/234	×1	4	
					91/290 – 91/311	×1	2,4	
MRK 841	15 04 01.1	+10 26 19	Sy	0.036	92/107 – 92/114	×2	2	
3C 390.3	18 42 08.9	+79 46 17	Sy 1	0.056	91/290 – 91/304	×1	2	Y
					92/135 – 92/156	×2	2	Y
ESO 141−55	19 21 14.1	−58 40 15	Sy 1	0.037	92/219 – 92/224	×1	4	Y?
					92/240 – 92/245	×1	4	Y?
					92/289 – 92/303	×1	2	Y?
MRK 509	20 44 09.6	−10 43 25	Sy 1	0.034	92/303 – 92/308	×1	4	
PKS 2155−304	21 58 51.8	−30 13 31	BL Lac	0.17	92/289 – 92/303	×1	2	Y?
4C 04.77	22 04 17.5	+04 40 02	BL Lac	(8400)	92/233 – 92/240	×2	2	
NGC 7314	22 35 45.6	−26 03 03	Sy 1.9	(1422)	92/119 – 92/128	×2	4	
NGC 7582	23 18 23.1	−42 22 12	Sy 2	(1575)	91/346 – 91/361	×1	2	
					92/093 – 92/114	×2	2	