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UNIVERSITY OF MARYLAND AT COLLEGE PARK

ASTRONOMY PROGRAM

7N-89-CR
190220

Dr. Yoji Kondo,
NASA Goddard Space Flight Center,
Code 684,
Greenbelt, MD 20771

Aug 19 1991

Dear Yoji,

I enclose the final technical report on NASA grant NAG5-1079 (U.Md. FAS 01-5-26944) "A Multi-frequency Investigation for Evidence of Anisotropic Continuum Emission in Seyferts". Please let me know if any other documentation is required.

Regards,
Yours Sincerely,

Andrew S. Wilson

Andrew S. Wilson

cc Valorie Burr Code 280.1
Booker McManus ORAA
Sharon Elliott
Erica Magrum ORAA

(NASA-CR-193621) A MULTI-FREQUENCY INVESTIGATION FOR EVIDENCE OF ANISOTROPIC CONTINUUM EMISSION IN SEYFERTS Final Technical Report (Maryland Univ.) 2 p

N94-70360

Unclas

Z9/89 0180220

ASTRONOMY PROGRAM • UNIVERSITY OF MARYLAND • COLLEGE PARK, MARYLAND 20742
TEL: (301) 454-3001 • TWX: 710-826-0352 ASTRONOMY CORK • FAX: 301-454-2298

FINAL TECHNICAL REPORT ON GRANT NAG5-1079 (U.MD. FAS 01-5-26944) "A Multi-Frequency Investigation for Evidence of Anisotropic Continuum Emission in Seyferts"

P.I.: Dr. Andrew S. Wilson (University of Maryland)
Co-I's: Dr R.R.J. Antonucci (University of california, Santa Barbara)
Dr. Anne Kinney (Space Telescope Science Institute)
Dr. Martin J. Ward (University of Washington/University of Oxford)
Dr. Mark Whittle (University of Virginia)

NASA-CR-193691

The primary aim of this project has been to thoroughly examine the evidence for anisotropic continuum emission in Seyfert galaxies. In performing this work, we have used archival data from the Einstein, IUE and IRAS missions, obtained new IUE obsevartions, and obtained new optical ground-based observations to complement the IUE data.

Prior to our work, IUE spectra were available for only about 3 type 2 Seyfert galaxies. Using a newly developed extraction technique, we analysed all 54 IUE spectra of 15 Seyfert 2's. Continuum detections were made for all 15 galaxies and reliable ultraviolet spectral slopes could be determined for 8 galaxies. Optical spectra were also obtained at Lick Observatory through a similar size aperture to the IUE observations, so that the entire spectrum from 1200 to 7000 Angstroms could be investigated free from aperture dependent effects. In addition to the power law fits to the continuum, line strengths were measured for Lyman alpha, Hbeta and Halpha. By extrapolation of the IUE continuum spectra into the ionizing ultraviolet, the apparent number of ionizing photons (Nion) could be determined. This number was then compared with the number necessary to power the observed Hbeta emission (Nrec). In a simple isotropic model the ratio Nrec/Nion = C < 1, where C is the covering factor of the ionized gas as viewed from the continuum source. In the occultation/reflection picture of Seyfert 2's, however, Nrec/Nion = C/f, where f is the fraction of ionizing radiation scattered into the line of sight. Thus, photon ratios Nrec/Nion > 1 indicate an anisotropic or occulted central source, even for the most conservative estimate of C = 1.

Our measurements of the photon ratios indicate that the ionizing continuum is emitted anisotropically for at least 6 of the 8 objects with uv slope measurements. The median value of the uv slope for the galaxies with slopes measured to better than +/-0.5 is alpha = -1.35 (Fnu propn nu**alpha), which is indistinguishable from the uv slope of Seyfert 1 galaxies. This result strongly suggests that in the occultation/reflection picture of Seyfert nuclei, the reflecting particles are free electrons rather than dust. Although there is some spread in the measured slopes, the spread is less than would be expected for spectra strongly affected by dust, which suggests that the continua are not highly reddened.

We verify previous observations of variability in Mkn 477. Mkn 477 seems to have some traits of a Seyfert 1 galaxy, such as continuum variability and a low ratio of Hbeta photons, indicating a direct view of the nucleus, while at the same time showing characteristics of a Seyfert 2 galaxy, such as a lack of broad emission lines and a high F([OIII]5007/F(Hbeta) ratio. The results of all the above described work have been published (Kinney, Antonucci, Ward, Wilson, and Whittle, 1991 Astrophysical Journal 377, 100).

During a visit to the CFA in 1990, the Einstein Satellite archives were searched for observations of the 59 AGN listed in table 1 of our grant application. Of the sample, 14 objects had no Einstein observations. In the remaining sub-sample 17 are bright Seyfert 1s, which have extensive published X-ray fluxes and spectra. We concentrated our efforts on the fainter sources, including a number of objects for which no published X-ray data are available. We analysed 35 separate IPC scans, of 26 individual AGN. For those cases where a few hundred counts were detected, we obtained spectral fits. This spectral analysis was carried out for the 9 brightest sources, and model fits were made in terms of the column density, spectral index, and X-ray flux (over a defined energy band).

Comparison was made with the results of the survey by Kruper, Urry and Canizares 1990 Astrophysical Journal Suppl. 74, 347 (1990). There were about a dozen objects in common. We found good agreement for most of the sources, as expected since we analysed the same data. However, we found very poor agreement for a few sources. On investigation we discovered that one of the computer packages previously in general use for the data reduction was unsuitable for application to long time-lines of data. We used a modified reduction programme and are confident of our results. The X-ray data will be used to constrain estimates of the number of ionizing photons, which will then be compared with the fluxes of the Balmer lines. More generally the data will be used in a statistical comparison of the X-ray properties of Seyfert 1s and 2s.

We have also determined the fluxes of all our sample in the four IRAS bands. We are currently putting together the entire spectra of our sample, covering 100 microns to 3 kev. This is by far the most complete broad band spectral investigation of Seyfert 2 galaxies. It will be used to search for anisotropy in the escape of radiation responsible for heating the dust which radiates the thermal infrared, usung the method described by Wilson, Ward and Haniff Astrophysical Journal 334, 121 (1988). A publication is in preparation.

In work related to unifying schemes for active galactic nuclei, we have presented near-infrared spectroscopic observations of the central regions of the luminous radio galaxy Cygnus A (3C 405), and interpret these results in terms of an obscured quasar nucleus. We have detected strong emission in the molecular hydrogen lines v=1--0 S(1) and v=1--0 S(3), the strengths of which are plausibly accounted for through heating by the nuclear hard X-ray source. The large equivalent widths of these molecular hydrogen lines and the near-infrared narrow hydrogen recombination lines suggest that the observed nuclear continuum is strongly attenuated at 2 micron. Assuming Cygnus A obeys the good correlations between hard X-ray, broad hydrogen line and near-infrared continuum luminosities established for quasars with little reddening, the intrinsic strengths of broad Palpha and the 2.2 micron continuum may be estimated empirically. Our observed upper limit to the flux of broad Palpha then implies an extinction to the putative broad line region Av(BL) of at least 24 mag, and the observed continuum intensity of the nuclear point source at 2. 2micron gives an extinction Av(NC)=54+/-9 mag towards the optical-infrared continuum. These estimates are consistent with the gas column density inferred from the low energy X-ray cut-off. We also report strong [Si VI]1.962 micron line emission from Cygnus A, the first such detection in a radio galaxy.

Bibliography of Papers in Refereed Journals supported by the Grant

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A. S. Wilson

Andrew S. Wilson
P.I. NAG5-1079