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FINAL TECHNICAL REPORT

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Project Title: Temporal and Spectral Studies of Seyfert Nuclei

Contract #: NAG8-289

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Amount: \$18501

Final Report:

In this proposal we proposed to (A) carry out data analysis of some carefully selected Seyfert sources; and (B) construct physics models for radiation from these object and carry out comparison with the observed data. The results of our investigations are outlined below.

(A) Data Analysis:

With Tsuruta as PI, the data analysis of (i) MCG-6-30-15, (ii) NGC 7469, and (iii) NGC 4593 were carried out by Tsuruta and her students. The results are summarized below.

(i) **MCG-6-30-15:** This is one of the strongest, closest and most rapidly and violently variable Seyfert 1 nucleus. The combined analysis of the data from multiple Ginga observations was the major portion of the observation-related work of R. Sivron's Ph.D thesis, which was supervised by S. Tsuruta and H. Kunieda. It was already published in (1) and (2). To improve the statistics R. Sivron and A. LeRoux (both students of Tsuruta at MSU), H. Kunieda and S. Tsuruta have been carrying out combined analyses of these Ginga data together with even better ASCA data now available. The work has been only recently completed, and we are now submitting two papers on our results for publications in Ap.J. (Astrophysical Journal)(3)(4). The major findings are: (a) the soft X-rays and hard reflection hump X-rays appear to be correlated; (b) the careful combined analysis of O VII and O VIII absorptions point to the possibility that both lines come from the same physical region.

(ii) **NGC 7469:** Our analysis showed that it exhibited interesting spectral variability, and the results are published in (5). Our results for the combined analysis with the ROSAT data are to be published in (6).

(iii) **NGC 4594:** We carried out combined analysis of our Ginga and ASCA data of this source (to increase statistics). The work was a major portion of the observation part of M. Kellen, Tsuruta's student at MSU. We are now preparing our final results for publication(7). The preliminary version was published in (8).

This grant also supported the continuing work (from previous period) to complete our data analysis of NGC 6814(9).

Physical Model:

We also proposed, in this proposal, to construct promising physical models of the central engine, which can be compared with the results from the data analysis. During the grants period, we partially completed the construction of two promising physical models: (i) disk-corona model, and (ii) cloud model.

(i) **Disk-Corona Model:** This was the continuation of the work already started before the grant period. The simplest model, where the reprocessing of softer photons from cold disk by hard radiation from the hot coronal plasmas was already published in (10)(11). During this grant period Kellen and Tsuruta improved on this model, by including the two-way interactions to construct a more realistic self-consistent model. Also input microphysics was significantly updated and improved. The results showed that this model is consistent with all the observational data currently available. The preliminary results are published in (8)(12). The more complete results are to be published soon(13).

(ii) **Cloud Model:** Another promising model for the spectra and dynamical behavior of Seyfert I nuclei radiation is a cloud model. During this grant period Sivron, Caditz (Tsuruta's postdoc) and Tsuruta constructed a cloud model, which showed that this model also explains all major observed data of Seyfert I nuclei and is dynamical behavior. But we predicted that future better observations should be able to distinguish between these two competing models. The results are published in (1), (14), and (15).

PUBLICATIONS directly related to this grant:

- (1) "Dynamical and Spectral Behavior of Seyfert Nuclei", 1995, Ph.D. Thesis, Montana State University, by R.Sivron
- (2) "Ginga Observation of MCG-6-15-30", 1994, B.A.A.S., R. Sivron, H. Kunieda and S. Tsuruta
- (3) "O VII and O VIII Lines of MCG-6-15-30", 1997, to be submitted for Ap. J., by A. LeRoux, R. Sivron, H. Kunieda and S. Tsuruta
- (4) "Spectral Variability of MCG-6-15-30", 1997, to be submitted for Ap. J., by R. Sivron, H. Kunieda and S. Tsuruta
- (5) "Observations of NGC 7469 and Akn 120", 1993, M.N.R.A.S., Vol. 265, p. 996, by W.M. Brandt, A. Fabian, N. Nandra, and S. Tsuruta
- (6) "X-Ray Spectral Variability in NGC 7469", 1996, Ap. J., Vol. 462, p. 158, by K. Leighly, H. Kunieda, H. Awaki, P. Zycki, and S. Tsuruta
- (7) "Spectral and Temporal Variability of NGC 4594", 1997, Ap. J., to be submitted, by M. Kellen, H. Kunieda, A. LeRoux and S. Tsuruta
- (8) "Temporal and Spectral Studies of Seyfert Nuclei", 1997, Ph.D. Thesis, Montana State University, by M. Kellen

- (9) Evidence for X-Ray Flux and Spectral Modulation by Absorption in NGC 6814: The Nature of the Fastest Variability", 1993, Ap. J., Vol. 421, p. 69, by K. Leighly, H. Kunieda, Y. Tsusaka, H. Awaki, and S. Tsuruta
- (10) "Some Models of Active Galactic Nuclei", 1989, Ph.D. Thesis, Montana State University, by B. Tritz
- (11) "Pair Plasmas in the Central Engine of Active Galactic Nuclei", 1993, in Plasma Physics and Controlled Nuclear Fusion (eds. T.D. Guyenne and J.J. Hunt), ESA Pub. Div., p. 137, by S. Tsuruta and B. Tritz
- (12) "Disk-Corona Model with Non-thermal Pair Production", 1995, Ap. J. Lett., Vol. 453, p. L9, by S. Tsuruta and M. Kellen
- (13) "Self-Consistent Disk-Corona Model of AGN", 1997, Ap. J., to be submitted, by S. Tsuruta and M. Kellen
- (14) "Dense Clouds near the Central Engine of AGN", 1993, Ap. J., Vol. 402, p. 420, by R. Sivron and S. Tsuruta
- (15) "Effects of Shocks on Emission from Central Engine of AGN - I", 1996, Ap. J., Vol. 469, p. 542, by R. Sivron, D. Caditz and S. Tsuruta