中国科学技术大学

硕士学位论文

低光度塞弗特2星系和活动星系核统一模型

作者姓名：　Kesselly Alton Vanie

学科专业：　天体物理

导师姓名：　王俊贤　教授

完成时间：　二〇一一年七月一日

University of Science and Technology of China

A dissertation for Master's degree

Low Luminosity Seyfert 2 Galaxies and AGN Unification Models

Author's Name : Kesselly, Alton Vanie

Speciality : Astrophysics

Supervisor : Prof. Junxian Wang

Finished Time : July 2011

中国科学技术大学学位论文原创性和授权使用声明

本人声明所呈交的学位论文，是本人在导师指导下进行研究工作所取得的成果。除已特别加以标注和致谢的地方外，论文中不包含任何他人已经发表或撰写过的研究成果。与我一同工作的同志对本研究所做的贡献均已在论文中作了明确的说明。

本人授权中国科学技术大学拥有学位论文的部分使用权，即：学校有权按有关规定向国家有关部门或机构送交论文的复印件和电子版，允许论文被查阅和借阅，可以将学位论文编入有关数据库进行检索，可以采用影印、缩印或扫描等复制手段保存、汇编学位论文。

保密的学位论文在解密后也遵守此规定。

作者签名：____________

年　　月　　日

ABSTRACT

Using Shu et al., 2007's "Investigating The Nuclear Obscuration in Two Types of Seyfert 2 Galaxies' (Shu et al., 2007)" as a prototype, we demonstrated that high signal-to-noise ratio and better spatially resolved data can account for some of the observations that are inconsistent with the Unification models of Active Galactic Nuclei. New data for the relatively low luminous seyfert 2 sources ((seyfert 2 with luminosity $< 10^{41} erg/s$), which wouldn't be incorporated in the conclusions of Shu et al., 2007, are sought for and analyzed, to examine whether doing so would lead to the inclusion all of all of Shu et al.'s sample into their conclusions. We accomplished that task successfully and then embarked on the slippery slope of questioning some highly cherished concepts upon which current understandings of Active Galactic Nuclei are anchored and in doing so provided personal perspectives on the way forward for a comprehensive understanding of AGN.

Keywords: AGN

Contents

Chapter 1

Introduction

The Universe is the playground for vast array of fascinating and complex phenomena. One of the most fascinating and somewhat mysterious of these fascinating and complex phenomena is Active Galactic Nuclei (AGN).

Active Galactic Nuclei is the generic name given to phenomena in which prodigious amount of rapidly varying radiations, which are emitted across the entire electromagnetic spectrum, are observed to be coming from very small distant regions.

In this thesis, the Unified Models of Active Galactic Nuclei will be subjected to critical scrutiny. The goal is to test whether higher signal-to-noise and better and spatially resolved data can get rid of some of the observed inconsistencies associated with the Unification models of Active Galactic Nuclei (AGN). Also, impressions about the current trends in AGN studies will be given and a personal perspective on the way forward will be proffered.

Chapter 1 takes a quick voyage through the defining characteristics of Active Galactic Nuclei and set the basis for the arguments in subsequent chapters.

In Chapter 2, the Unification schemes for Active Galactic Nuclei is introduced, some inconsistencies with AGN Unification schemes are discussed and a procedure that will be used to test whether the inconsistencies with AGN unification models noticed in some low luminous Seyfert 2 galaxies are real or those inconsistencies are the result of poor data collection and analyses.

The old analyzed low luminous Seyfert 2's data, from which conclusions were drew, are placed side by side with new, better, spatially resolved, and higher signal-to-noise ratio data of the same sources and the similar procedures that lead to the observations of inconsistencies with the Unification models are carried out in Chapter 3. Discussions and conclusions about the analyzed data are also offered in Chapter 3.

Chapter 4 summaries the entire thesis and concludes with personal perspectives and suggestions.

Historical Timeline

Given that the nomenclatures, characteristics and taxonomy of Active Galactic Nuclei are interwoven with the history of the discovery Active Galactic Nuclei, it is only fair that a brief historical timeline of Active Galactic Nuclei be provided. Hopefully, the provision of a historical timeline will help makes reading this work easier.

1908 Edward A. Fath observed emission lines similar to planetary nebulae in NGC 1068

1917 Vesto Slipher confirmed that bright and dark lines were present in the spectrum of NGC 1068

1926 Edwin Hubble mentioned that NGC 1068, NGC 4051 and NGC 4151 Show planetary nebula-type spectrum

1943 Carl Seyfert recognized spiral galaxies with optical emission lines as a class

1954 Walter Baade and Rudolph Minkowski found optical counterparts to the radio sources Cyg A, VirA and Per A

1959 Lodewijk Woltjer suggested that AGN have huge masses

1963 Maarten Schmidt identified lines of the radio source 3C 273 and calculated its distance, showing that AGNs are very far away

1964 Salpeter and Zeldovich independently suggested that the idea of accretion onto a supermassive Black Hole as the source of energy production in AGN

1969 Lyndell-Bell suggested that Supermassive Black Holes should be common in galaxies

1970 Uhuru, the first X-ray satellite is put in orbit and it is operational up o 1973

1974 E. Y. Khachikian and D. W. Weedman defined two sub-classes of Seyfert galaxies

1975 Ariel V data showed that X-rays are common property of Seyfert

1977-1979 HEAO1 carried out the first all sky X-rays survey

1979-1980 Einstein gave images of thousands of AGNs

1983 IRAS is launched and gave the first infrared AGN observations

1978 Blanford and Rees proposed the first Unification scheme

1999 Chandra and XMM are launched

Observational Properties

To be called an Active Galactic Nuclei, an object or phenomenon must have very high luminosity, relatively small angular size and rapid irregular observed radiation.

Active Galactic Nuclei are observed to have luminosities between 10^{42}-10^{48} ergs $^{-1}$, emitted almost equally across the entire electromagnetic spectrum. In other words, Active Galactic Nuclei have flat νFν spectra (Krolik, 1999). The spectra of AGN exhibit broadband continuum and broad emission lines.

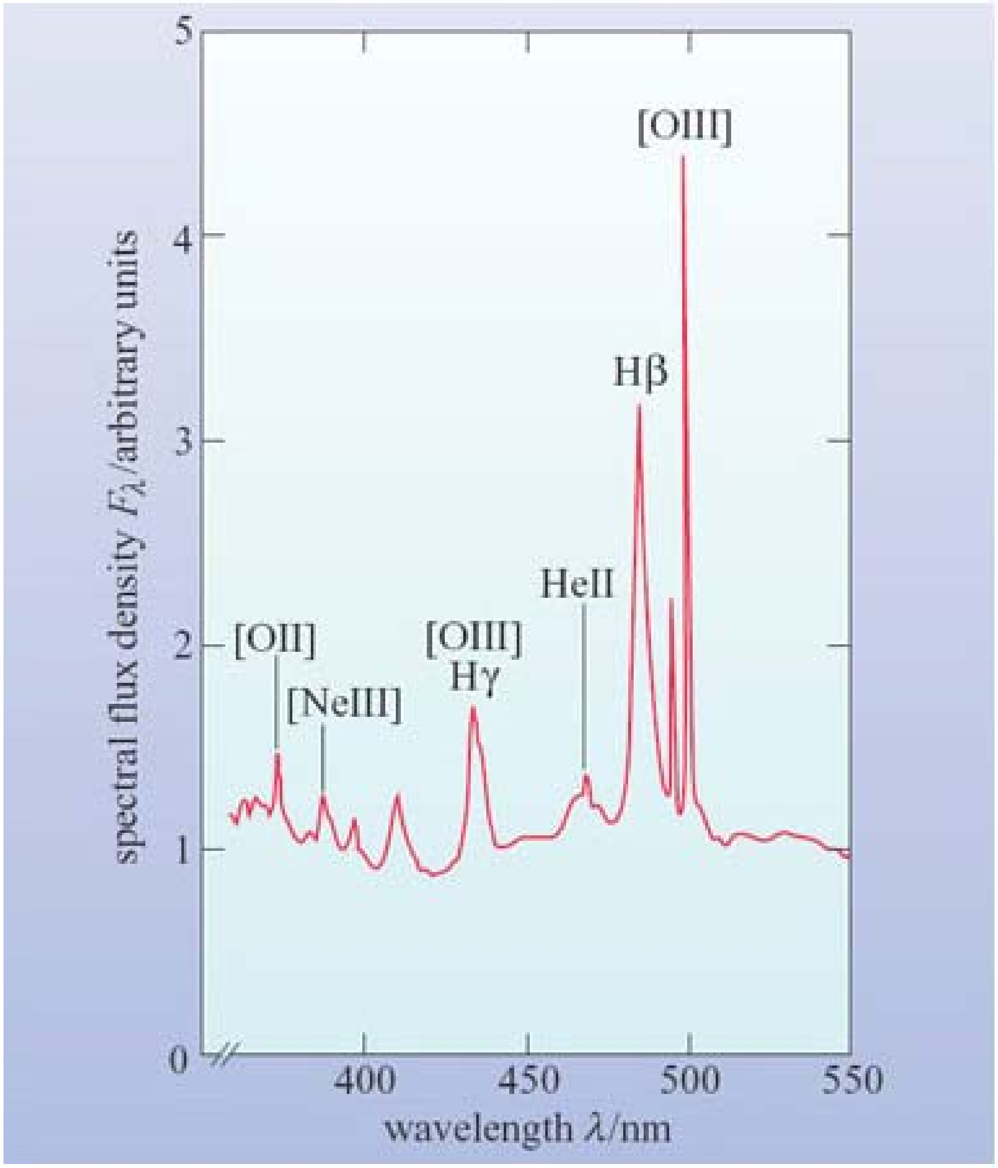


Figure 1: The Schematic optical spectrum of an active galaxy (1)

Rapid variations differing across the electromagnetic spectrum are common among Active Galactic Nuclei. These variations can be attributed to either intrinsic causes such as instability in the accretion disk or to external factors (Blandford et al., 1990).

The fact that Active Galactic nuclei are spatially unresolved couple with the Variability of their radiations on timescales as short as minutes together with light crossing arguments can be used to show that the angular size of Active Galactic Nuclei is relatively small.

The small angular size of AGNs, their very high luminosities and rapid variations suggest that their radiations are not produce by nuclear fusion (Fixed, 2001).

The Structure of AGN

Observations of the luminosities of AGN across the various frequency bands couple with certain theoretical considerations portray Active Galactic Nuclei as containing Supermassive Black Holes, Accretion disks, Dusty tori, Broad Line Region (BLR), Narrow Line Region (NLR) and Bi-polar jets.

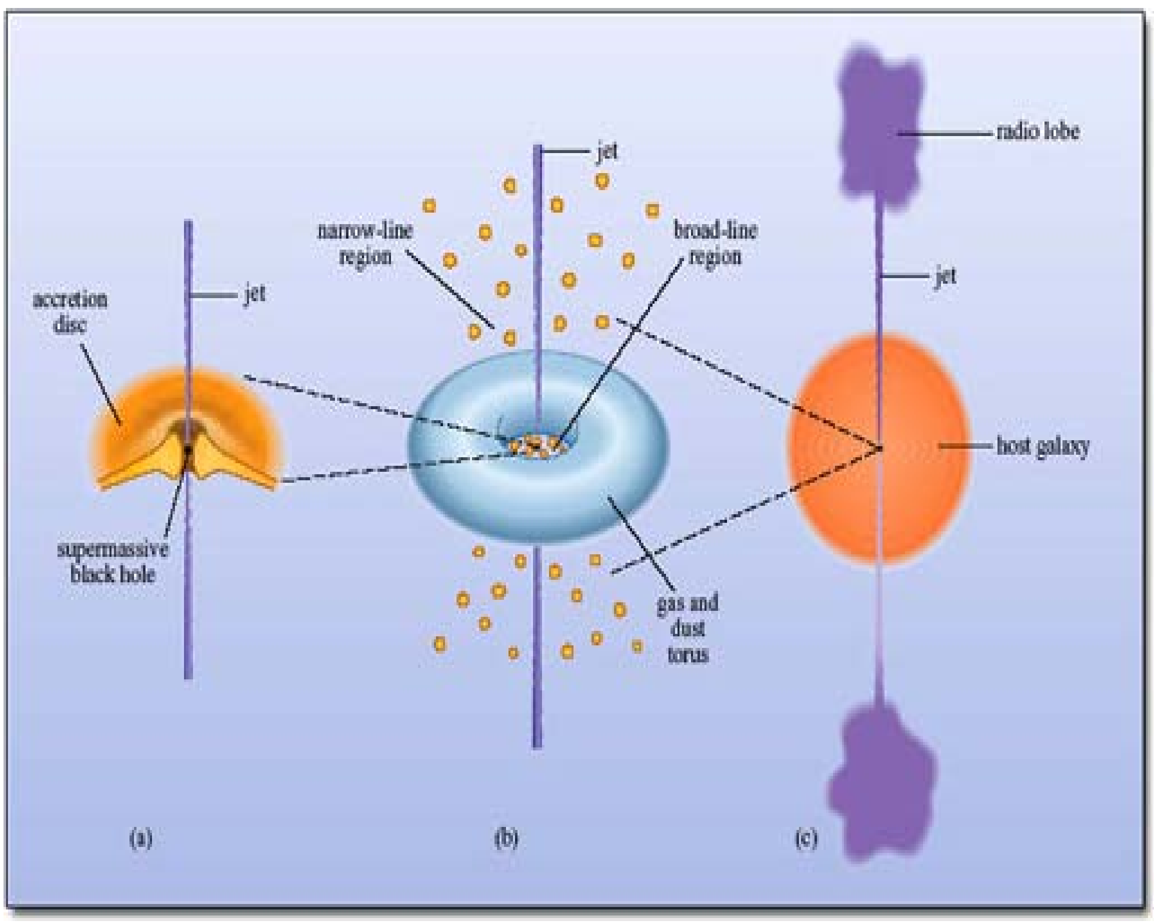


Figure 2: The General model for an active galaxy. (a) the central engine (b) obstructing torus (2)

A Black Hole is the vacuum solution to the Einstein Field Equations. It is defined by an event horizon and a singularity. It can be completely characterized by only three *externally* observable classical parameters: mass, electric charge and angular momentum (the so-called no hair theorem). (2)

Supermassive Black Holes are Black Holes whose masses have been confined to between 10^6 to 10^{10} solar masses by the Eddington and the Roche limits.

The efficiency of SMBHs in the conversion of gravitational potential energy into radiation, the inevitability of the existence of SMBHs from either merger of several compact objects or the complete collapse of entire galaxies and the stability of SMBHs over aeon of time enforces the belief that Supermassive Black Holes are the engines of AGNs (Camenzind, 2007). This belief has been reinforced with the discovery of broadened and skewed iron Kα emissions in X-ray (Nandra et al., 1997).

It is still uncertain how the original Black Hole formed.

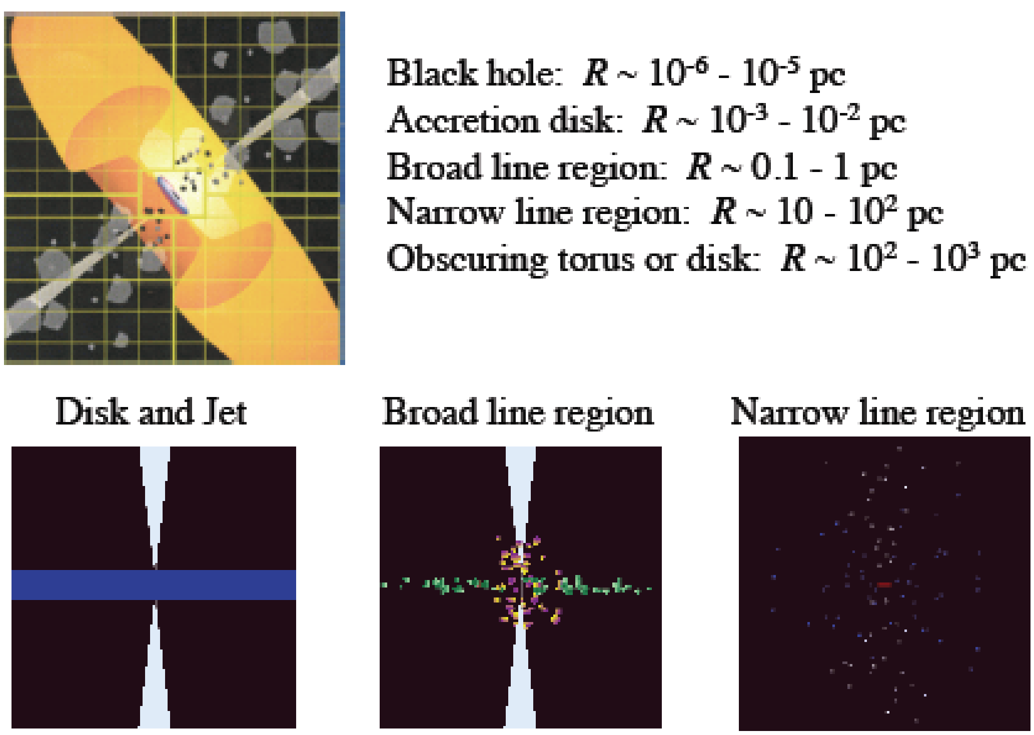


Figure 3: Some structure of AGN (3)

Since the average stars in galaxies have 10^5 times more angular momentum than the maximum permitted for accretion onto a supermassive Black Hole, there must be some mechanisms that can efficiently remove angular momentum from materials orbiting in galaxies if accretion onto a Black Hole is to be possible (Fixed, 2001).

The accretion disk is hypothesized to be the provider of such mechanisms. The accretion disk represents an effective mean of transporting angular momentum away from the Black Hole but transporting mass onto the Black Hole (Fixed, 2001).

The accretion disk is approximated to have a radius of 10^{-3} parseconds (Pc), a number density of 10^{15} cm^{-2} and the accretion disk is assumed to play many other roles in AGN activities such as being the source of the continuum emissions and also purported to be the launching site for the bipolar winds and jets. [(3)]

The forms, the dimensions, efficiency and emissivity of the accretion disk depend on whether the black hole is rotating (Kerr's Black Hole) or not (Schwarzchild's Black Hole).

The torus is supposed to consist of dust whose composition is not clearly defined and gases (mostly hydrogen). The dust content of the torus sets the limit on the minimum radius it can have. The inclination of the torus with respect to an observer plays pivotal role in the classification of Active Galactic Nuclei. The infrared Bump (Barvainis, 1987) is purported to be an indirect evidence of the existence of the torus.

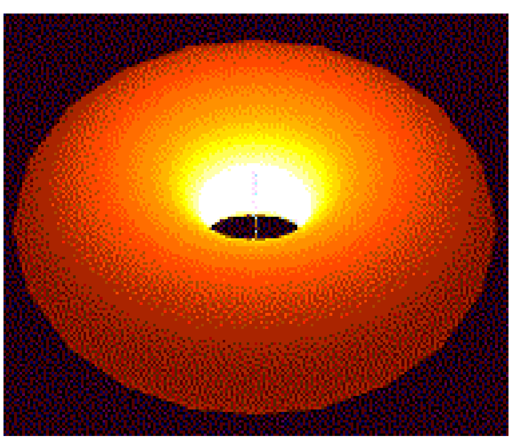


Figure. 4: Artistic imagination of a torus [(4)]

Regions relatively close to the accretion disk from which permitted broad emission lines are believed to originate are called the Broad Line Region (Kaspi et al., 2000; Petterson et al., 2004). The BLR is assumed to have radius between 0.01-0.1 pc and number density of 10^{10} cm^{-3} and velocities between 1000-5000 km/s and a temperature of 10,000 K. (3). The BLR geometry is poorly understood.

Farther from the accretion disk and beyond the torus is the region called Narrow Line Region (NLR) because of the absence of broad emission lines in spectra associated with it. Permitted and forbidden narrow emission lines are believed to originate from the NLR.

The NLR is assumed to have a radius between 100-1000 pc, a number density of 10^3-10^6 cm^{-3} and a temperature of 10,000 k. (3) It is the most extensive part of the AGN and envelops all the other components of the AGN (Fixed, 2001).

There is no general consensus on the precise mechanisms that produce jets in AGN but the widely accepted view is that magnetic fields in the inner accretion disk wrap around until they are locked into a double helix configuration which causes charged particles to accelerate to velocities close to the speed of light (see Blanford and Payne, 1982 for details).

Due to relativistic effects, the jets are beamed in a particular direction (Krolik, 1999). Thus, the sources in which the observer is located will appear anomalously bright.

Jets appear to be nature by-products of the accretion disk and may be the avenues through which the gases in accretion disk lose angular momentum.

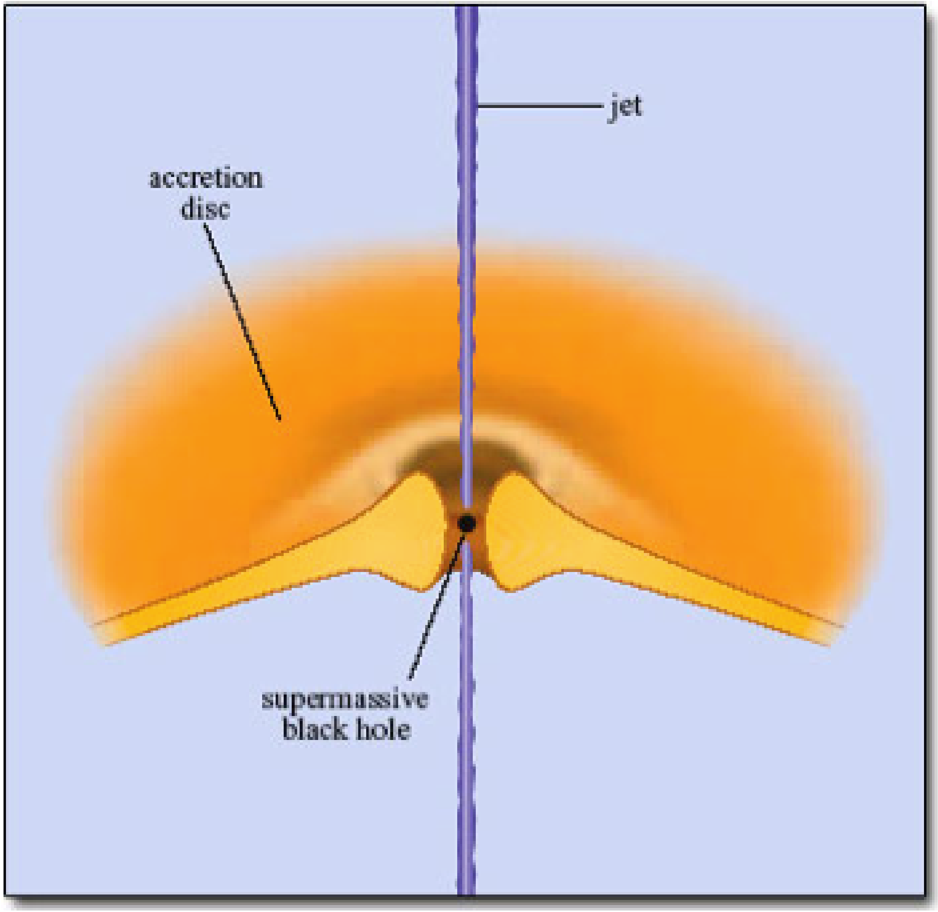


Figure 5: A scenario for the formation of jets in which inner region of an accretion disc Thicken to form two opposed funnels [5]

Radiative Properties of AGN

The radiations emitted by AGN seem to be the ideal window through which the nature of the physical processes occurring deep inside active nuclei can be understood. The different variations in radiation across different wavebands and the different conditions needed to produce these radiations can be exploited in order to reveal some of AGN deepest secrets.

Some of the prominent Radiative processes occurring in AGN are synchrotron radiation, Compton scattering, Inverse Compton scattering and thermal (or blackbody) radiation.
Synchrotron radiations are radiations that result from the acceleration of relativistic electrons in a magnetic field. Synchrotron radiation spectra can be approximated as a power law. Jets and radio spectra in AGN are attributed to synchrotron radiation.

Thus the characteristic frequency of the radiation is given by

$$\omega_c = \gamma^2 \omega_L = \frac{eB}{m_e c}\left(\frac{E}{m_e c^2}\right)^2$$

Compton scattering and Inverse Compton scattering are inelastic scatterings in which photons are deflected from their original paths due to their interactions with electrons. While Photon loses energies in Compton scattering, it gains energies in inverse scattering. The Photon spectra can be found analytically by solving the Kompaneets equation (see Sunyaev & Titarchuk, 1980 for detail). The X-ray spectra of AGN are attributed to Inverse Compton scattering.
Thermal or Blackbody radiation is the radiation that can be fully described by Planck radiation. It is the radiation expected from bodies that are in thermal equilibrium.

$$\frac{\mathrm{d}E}{\mathrm{d}A\,\mathrm{d}t\,\mathrm{d}\Omega\,\mathrm{d}\nu} = B_\nu = \frac{2h\nu^3}{c^2}\frac{1}{\exp(h\nu/kT)-1}$$

The infrared bump in AGN spectra is mainly attributed to the emission from dust with a temperature below the sublimation temperature of dust, T< 1500 K (Ree et al, 1969; Lebofsky and Rieske, 1980: Barvainis, 1987).

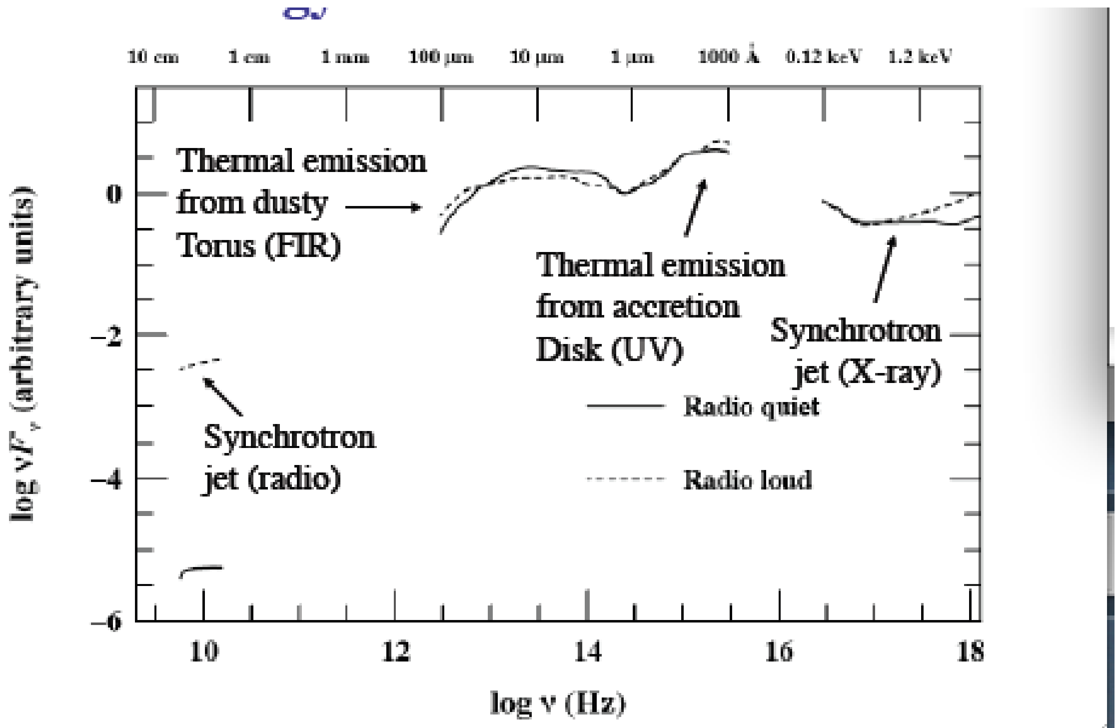


Figure 6: Different radiative processes in AGN and their associated phenomena (Elvis et al., 1994)

The Spectral Energy Distribution of AGN

Our direct diagnostics of AGN come from their observed radiation. The different and irregular variations across different wavebands indicate that wide varieties of mechanisms are at work and that different processes are involved in the production of radiations across the different wavebands.

Since AGN radiates equally well across the entire electromagnetic spectrum (Petterson, 1997) and because the spectra of AGN is our best chance of ever understanding the intrinsic properties of AGN and the mysterious physical processes occurring deep within them, there is the need to understand the emission and energy generation mechanisms that produce these spectra in order to fully comprehend the intriguing physics governing the behaviors of AGNs, to infer the actual mechanisms operating at the heart of AGN and be able to deduce global behaviors.

Lots can be learned through the analyses of the radio spectra, Infrared spectra, Optical/Ultraviolet spectra, X-ray spectra and combinations thereof of AGN.

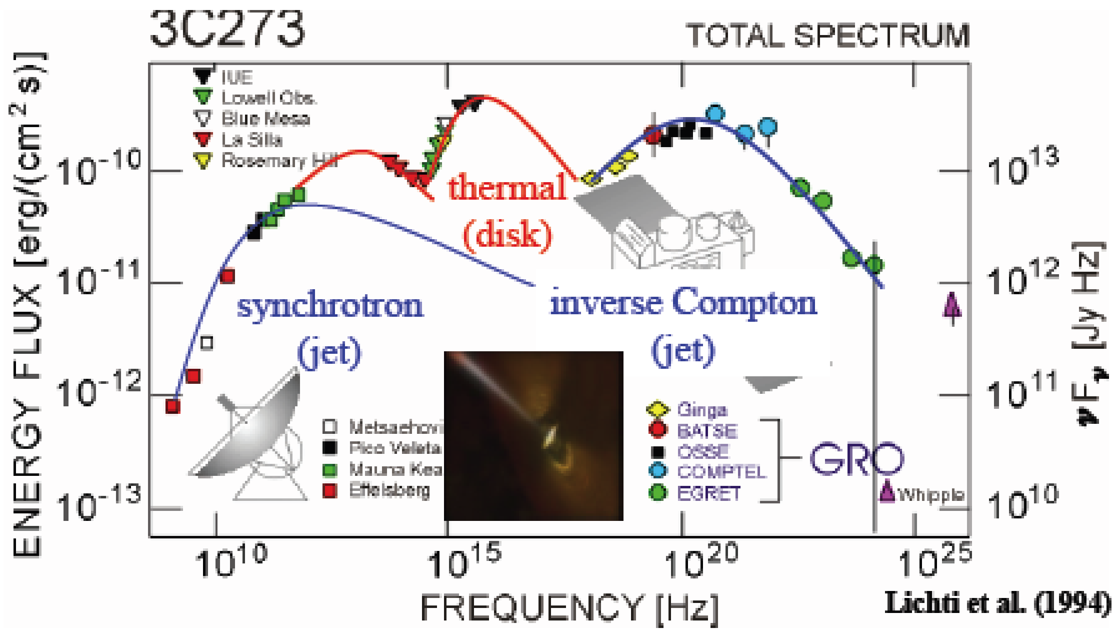


Figure 7: The SED of AGN

Ironically, AGNs were first discovered by their identification with radio sources when, in fact, most AGNs are radio-quiet and radio spectra provides a negligible fraction of the bolometric luminosity of AGNs.

Nevertheless, the radio spectra of AGNs provide essential information on the structures of AGNs and great insights into some of the physical processes occurring deep inside AGNs. The radio spectra of AGN provide all the known information about the jets and radio lobes of AGN, they are the only truly known mean through which AGNs can be spatially resolved and it is information from the radio spectra that give us constraints on the evolution of AGNs.

The Infrared spectra are believed to be reprocessed energy. It is generally assumed that most of the primary luminosity (mostly in the optical and ultraviolet regime) is absorbed and subsequently reradiated in the infrared by absorbing dust. Its thermal resemblance is the telltale of the presence of a torus.

The Optical/Ultraviolet spectra are dominated by the so-called Big Blue Bump, which is attributed to some kind of thermal emission from the accretion disk (Petterson, 1997 Malkan 1983, Sun & Malkan, 1989).

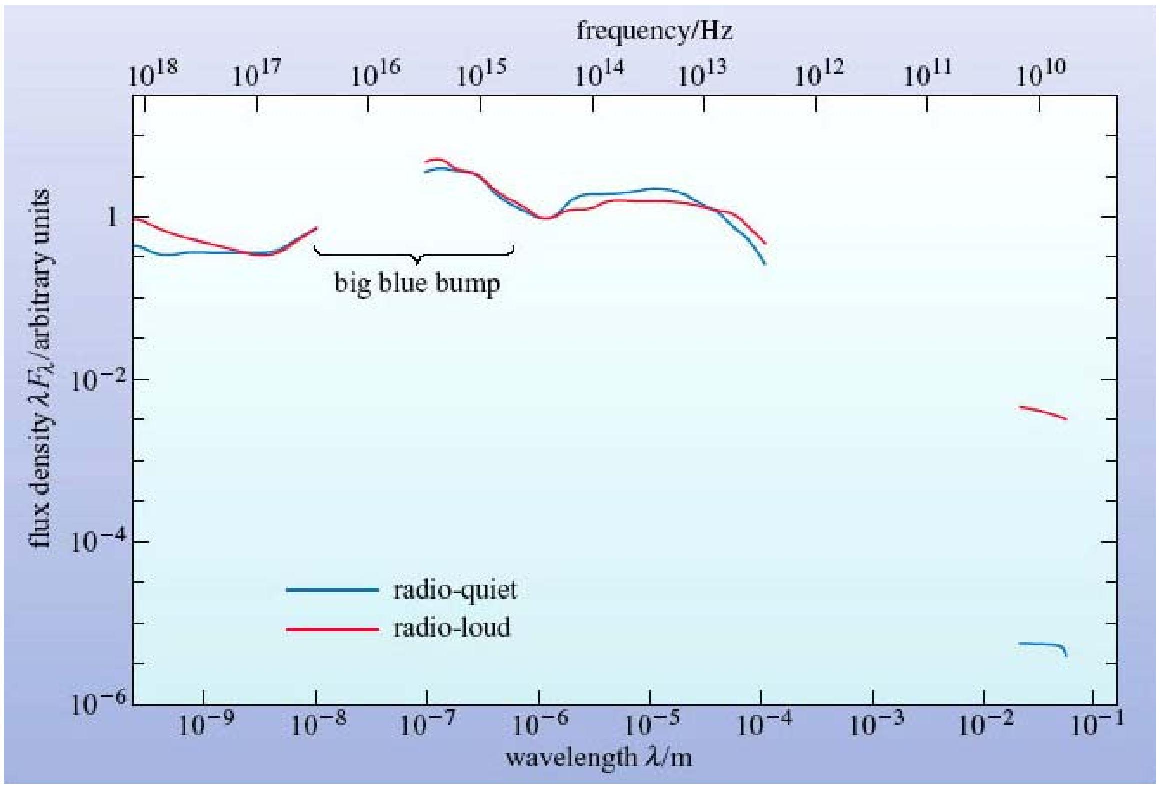


Figure 8: Illustration of the Big Blue Bump (courtesy of Wikipedia image)

The shape and peak of the Big Blue Bump provide important information on the structures and conditions of the accretion disk.

There are levels below 1kev for which there are no emissions. One is in the extreme Ultraviolet (EUV) while the other is in the millimeter wavelength band. The lack of emission in the EUV would be due the opacity of the ISM while the lack of emission in the millimeter wavelength is attributed to the opacity of the Earth's atmosphere (Petterson, 1997).

The X-ray spectrum is believed to be produced from inverse Compton scattering of optical/UV photons in the corona (Sunyaev & Titarchuk, 1980). Because AGNs emit more than three times the X-ray fluxes emitted in normal galaxies (Krolik, 1999; Petterson, 1997), X-ray emission is a good signal of the presence of an AGN.

It is of fundamental importance to know whether the AGN spectrum is from thermal emission (i.e., has shape of Planck function) or non-thermal. Without this information, the actual amount of radiation from a source would be wrongly inferred.

Taxonomy of AGN

The classification of Active Galactic Nuclei into sub-classes is very complex and confusing.

Most of this complexity and confusion stemmed from the history of AGN classification and from observational difficulties.

Historically, myriad of different observational criteria have been used for the taxonomy of AGN resulting in some objects finding themselves in more than one classes.

Also, some of the classifications are mere reflection of the history of AGN discovery rather than similarities among objects.

Moreover, the impossibility (either technically, resource-wise or even in principle) of obtaining full spectral coverage across the entire electromagnetic spectrum for all objects make it difficult, if not impossible, to reconcile classification based on one waveband with those done in other wavebands.

A Taxonomy of AGN based on their emission line characteristics would include the subclasses of Radio Galaxies, Quasars, Seyfert Galaxies, BLAZAR and LINERs.

The radio morphology of radio galaxies can be described in term an extended (spatially resolved) radio component and a compact (Spatially unresolved) component. These two components have different characteristics.

The Extended radio galaxies can be subdivided into Fanoraff-Riley type 1 (FR I) and type 2 (FR II).

FR I are nucleus dominant, less luminous than FR II, brightest at the center with decreasing brightness toward the edges. They have two broad asymmetric jets ending in plumes and they are generally weak radio sources. .(3)

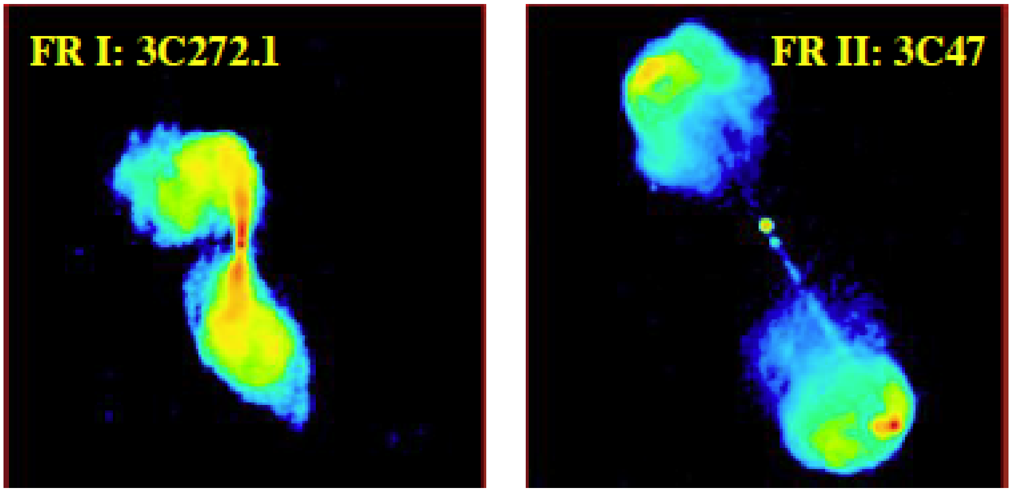


Figure 9: FRI and FRII (3)

(3) http://pulsar.sternwarte.uni-erlangen.de/wilms

FR II are lobes dominant; they are more luminous than FR I, they have weak jets ending in radio lobes and they are strong radio sources.(3)

Quasars or QSO are very distant and luminous. They are often found in elliptical galaxies. Most Quasars are radio-quiet.

Seyfert galaxies are considered as the less luminous counterpart of Quasars. They are normally found in spiral galaxies and their host galaxies are generally detectable.

Seyfert galaxies are sub-classed into Seyfert type 1 (Seyfert 1) and Seyfert type 2 (Seyfert 2).

Seyfert 1 optical spectra show both broad permitted emission lines and permitted and forbidden narrow emission lines whereas Seyfert 2 optical spectra show only forbidden and permitted narrow lines (Barger et al. 2005; Treister & Urry 2005).

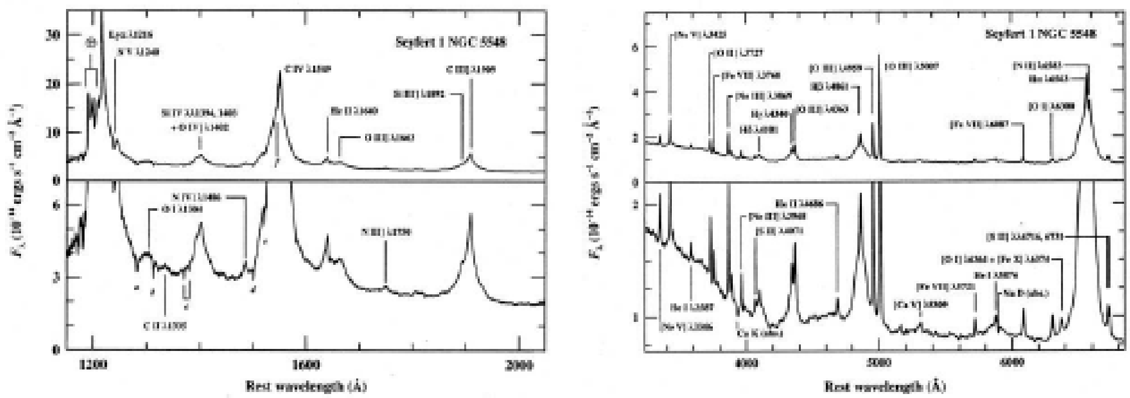
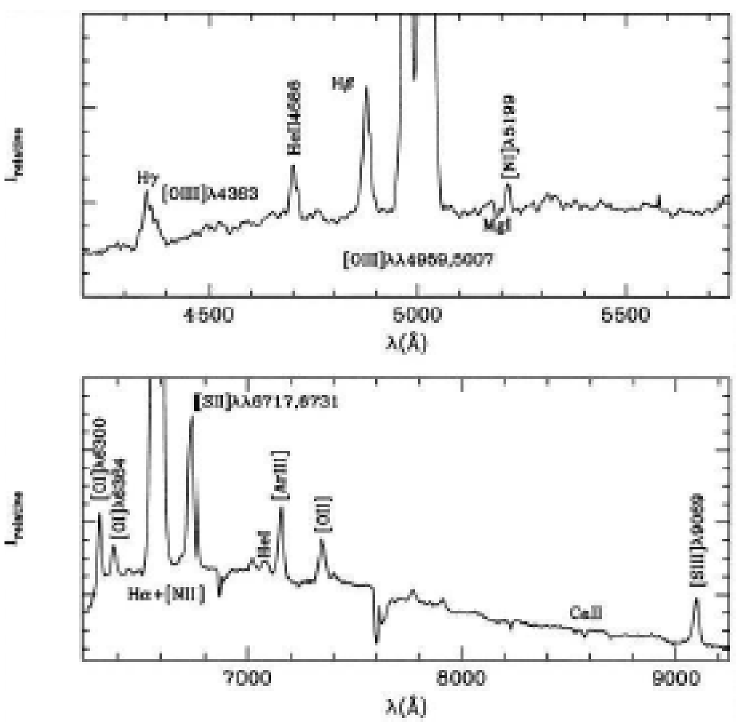


Figure 10: Spectrum of Seyfert1 [(3)]



(García-Lorenzo, Mediavilla & Arribas, 1999, Fig. 4)

Figure 11 Spectrum of Seyfert 2[(3)]

Blazars are unusually strong and rapidly varying radio sources with little or no emission lines. The two subclasses of Blazar are BL Lacertae (BL Lac) and Optically Violent Variables (OVVs).

OVVs exhibit extremely rapid and strong degrees of polarization and show strong radio emission.

BL Lac share most of the properties of OVVs but differ by having virtually featureless spectra.

Low Ionization Nuclear Emission Region Galaxies (LINERS) are characterized by emissions from weakly ionized or neutral atom. Their spectra are similar to those of Seyfert 2 except for the fact that they have weaker emission lines.

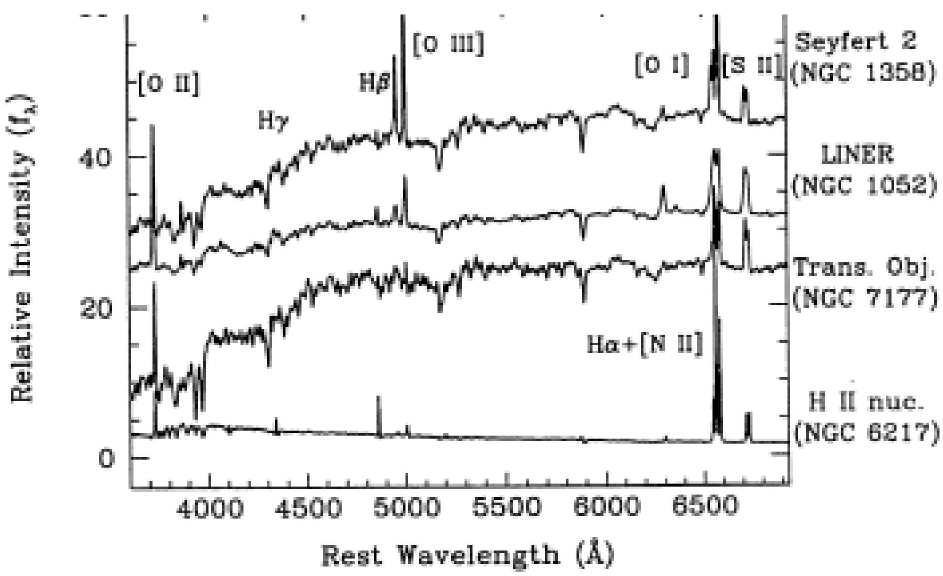


Figure 12: Optical spectra of Seyfert II, LINER and HII Nuclei (Ho, 1996)

There are still ongoing debates as to whether LINERs are powered by accretion onto SMBHs or by starbursts.

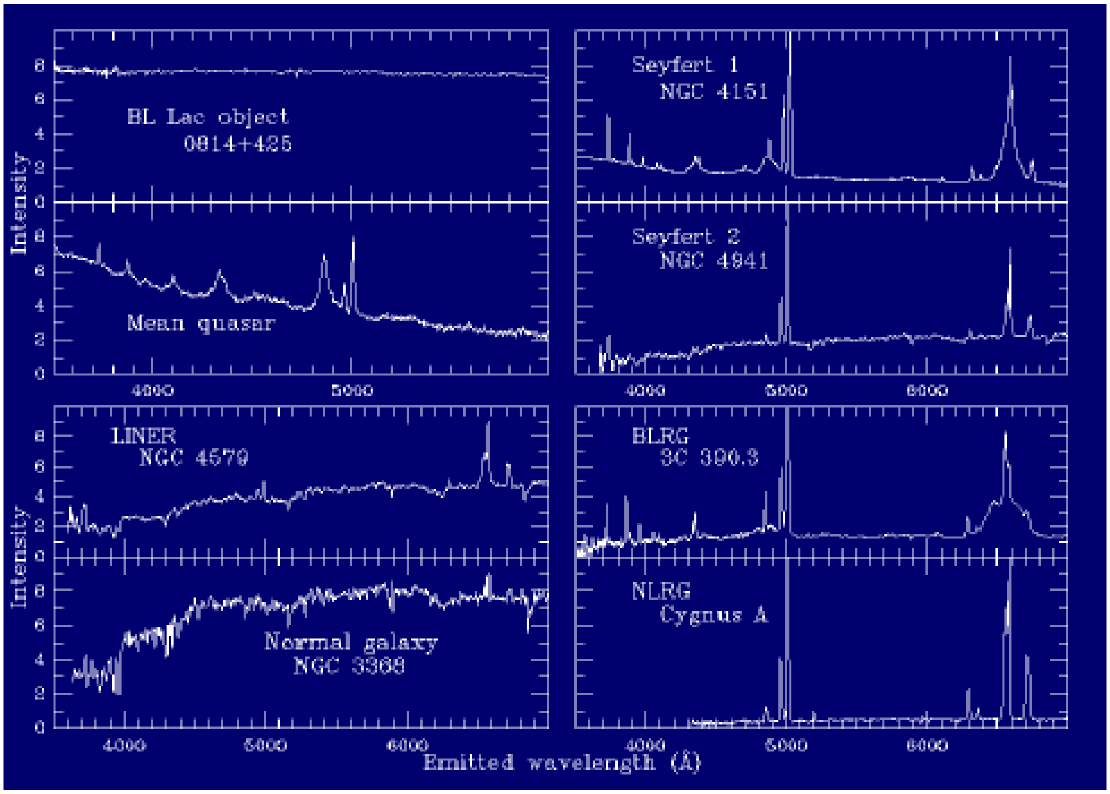


Figure 13: Optical Spectra of different AGN types [3]

Chapter 2

AGN Unification Models and Test

The Unification Models

Given that AGNs have similar structures (e.g., SMBHs, accretion disk, torus, etc) and that the same physical processes (i.e., accretion of mass onto a SMBH) seem to be at work in them, it would be truly unusual for the huge diversities among them to be intrinsic. It would be very strange for the many similarities among AGNs to be mere coincidence. The vast diversities among AGNs, if intrinsic, would be violation of the belief that any description of natural phenomena must be made as simple as possible as long as there is no evidence to the contrary (Occam's razor).

These poignant observations motivate the consideration of unifying schemes to explain the variety of features observed in AGN.

The Unified Models propound that the different subclasses of AGN are intrinsically the same and their observed differences are simply consequences of the size and the isotropy of the Luminosity, on one hand, and the inclination of the observer with respect to the active nucleus, on the other hand.

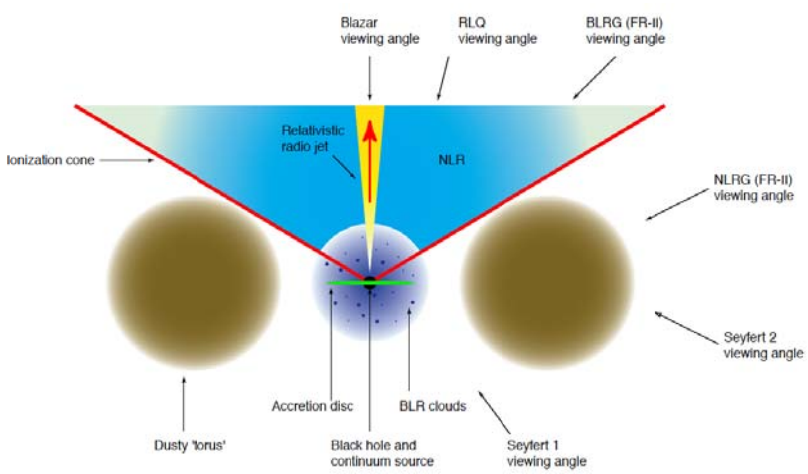


Figure 14: artistic illustration of the unified models

The size and the isotropy of the Luminosity can account for the radio-quietness and radio-loudness of Active Galactic Nuclei. According to this scheme, the radio-quietness and radio-loudness of an AGN depend on the alignment of the relativistic jet with the line- of -sight of the observer.

If the AGN is observed along its jets, the radiation from it would be dominated by the synchrotron radiation from the jets and the AGN is called a Blazar.

When it is viewed from the side, the torus obscured the active nucleus in the optics, but have little or no effect on the radio jets and the AGN appears as a radio galaxy. Obliquely viewed, the torus doesn't hide the nucleus and the AGN is classified as a Quasar (Krolik, 1999).

On the other hand, the diversities among radio-quiet Active Galactic nuclei can be attributed to the inclination of the molecular torus with respect to an observer.

The basic idea behind this version of the unification models is that the continuum emission from the accretion disk and emissions from the Broad Line Region (BLR) can be obscured if the orientation of the observer transverse the molecular torus but the continuum emission from the accretion disk and emissions from the Broad Line region broad are visible when the orientation of the observer doesn't intersect the torus [(3).]

Active Galactic Nuclei viewed through the region of obscuration, resulting in the Broad line regions being hidden from view, are tagged type-2 AGN (e.g., Seyfert 2) whereas those for which the Broad line regions are not hidden are dubbed Type-1 AGN (e.g., Seyfert 1).

This scheme of AGN unification is stretched to the logical conclusion that quasars and Seyfert1 are essentially the same type of object with the only intrinsic different between them being that quasars are more luminous.

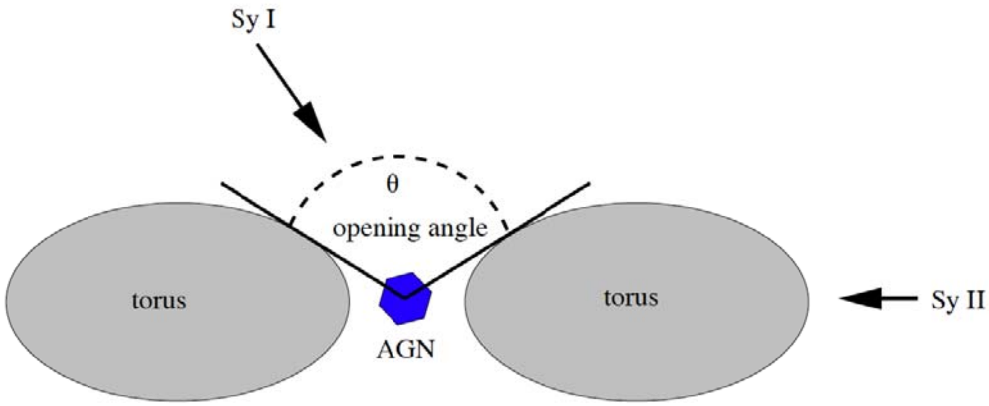


Fig. 15: Cartoon illustration of the Type-1 and Type-1 unification scheme (1)

One of the strongest evidence for the AGN Unification Models was the detection of scattered broad Hα lines in the Seyfert 2 galaxy, NGC 1068 (Antonucci and Miller 1985 and the further observations that this is not unique to NGC 1068 (Miller and Goodrich 1990, Young et al 1996, Heisler, Lumsden and Bailey 1997, Moran et al 2000, Lumsden et al 2001 and Tran 2001; Tran 2003; Inglis et al 1993, Hines & Wills, 1993; Tran, Miller and Kay 1992; Miller and Goodrich, 1990, Gu and Huang 2002; Tran 1995, Heisler et al 1997; Lumsden &Alexander 2001; Martocchia & Matt 2002).

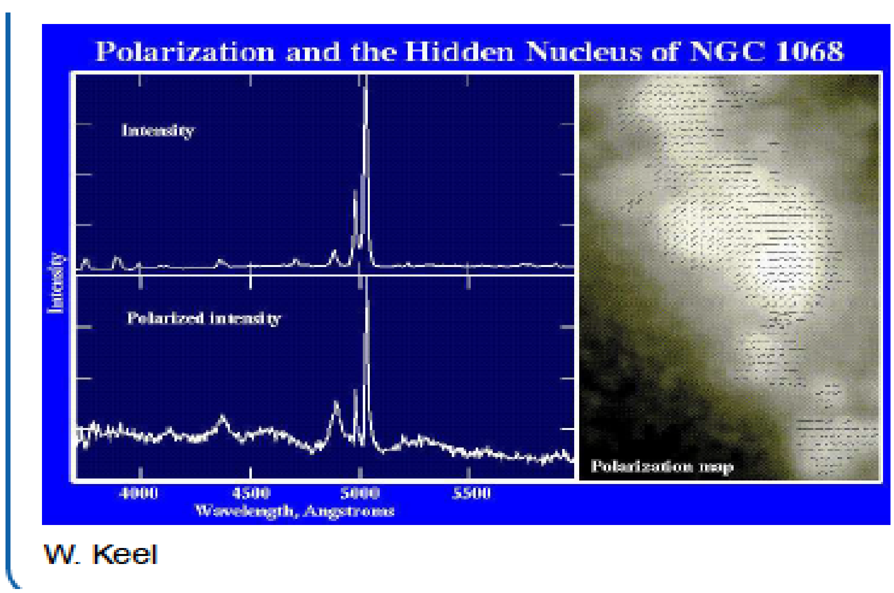


Fig. 16 Polarized Broad emission lines in the Seyfert 2 galaxy, NGC 1068(6)

Other evidences in support of Type-/Type-2 Unification model for Active Galactic Nuclei include:
Anisotropic continuum narrow emission line and the bi-conical structures of the narrow line region (Mulchaey et al 1996, Evan et al 1991, Pogge 1988, Wilson et al 1993, Robinson et al 1987, Baum and Heckman 1989; Tadhunter and Tsvestanov 1989; Wilson et al 1993), the similarity of the Co masses of the two Seyfert types (Maiolino et al 2007) and the similarity of their parsecond scale nuclear radio structures being similar in both types of Seyfert.

This Unification schemes are inundated with supporting evidences across the entire electromagnetic spectrum, including the infrared (Bailey et al 1986; Fabbiano et al, 1986, Hough et al 1987; Antonucci and Barvainis 1990, McCarthy et al 1990; Djorgovski et al 1991) and the X-ray (Awaki et al 1991; Smith and Done, 1996; Turner et al 1997, Bassini et al 1999; Cappi et al 2006, and Risaliti, Maiolino and Salvati, 1999; Bassani et al., 1999; Lawrence and Elvis, 1982; Fabbiano et al., 1986, Arnaud et al 1987; Ward et al 1991; Ueno et al 1994). The many supporting evidences together with beauty and simplicity make this unification models very appealing to the extent that it is inconceivable to think that these models would be wrong.
Because X-ray emission plays pivotal role in testing the validity of the Type-1/Type-2 AGN unification scheme, it is only logical that for completeness sake we briefly discuss the X-ray emission processes as a tool in testing Unification models.
Because the torus is purported to be composed of dust and gas and because the optical polarization of the featureless continuum in Seyfert 2 galaxies (e.g., NGC 1068) is wavelength independent across wide range of frequencies (code et al, 1993), the conclusion had been drawn that the scattering particles in the torus are gases rather than dust. This means that gases polarize optical spectra while dusts in the torus attenuate X-ray spectra. Thus, the X-ray band offers another independent mean of testing the Unified models.
From galactic dust composition (Schultz and Wiener 1975) and dust-to-gas mass ratio (Bohlin et al 1978; Kent et al, 1991), the relation between optical extinction and x-ray

extinction can be obtained and this relationship can be extrapolated to obtain a typical hydrogen column densities $N_H > 10^{22}$ cm^{-2} for obscured AGNs.

Assuming all our assumptions (e.g., universality of hydrogen –to-other elements ratio, that the intra and inter galactic dust-to-gas ratio is constant and uniform, etc), then one expects Type-1 AGNs to have X-ray column densities not higher than 10^{22} cm^{-2} whereas heavily obscured AGN (most type-2) should be Compton thick (Risaliti & Elvis 2004).

The implication of the aforementioned is that X-ray emissions from many Type-2 galaxies should be attenuated by the obscuring torus whereas hard X-ray (>2 kev) should pass easily passed through type-1 AGN sources.

Indeed, many observations dovetailed neatly in with the predictions of this unification scheme, particularly the aforementioned ones.

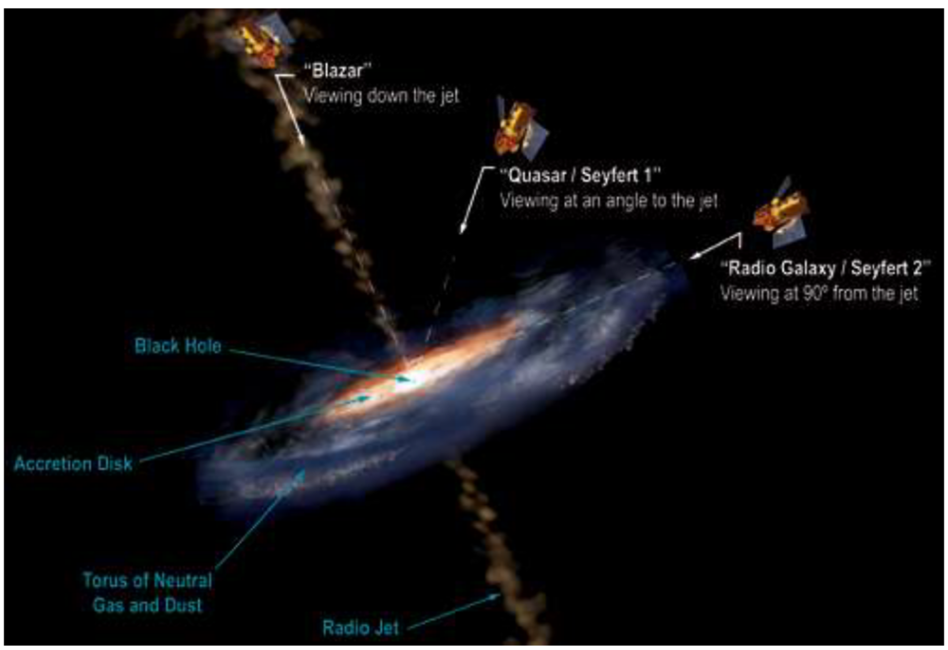


Fig. 17: Sc hematic illustration of the Unification models of AGN [(2)]

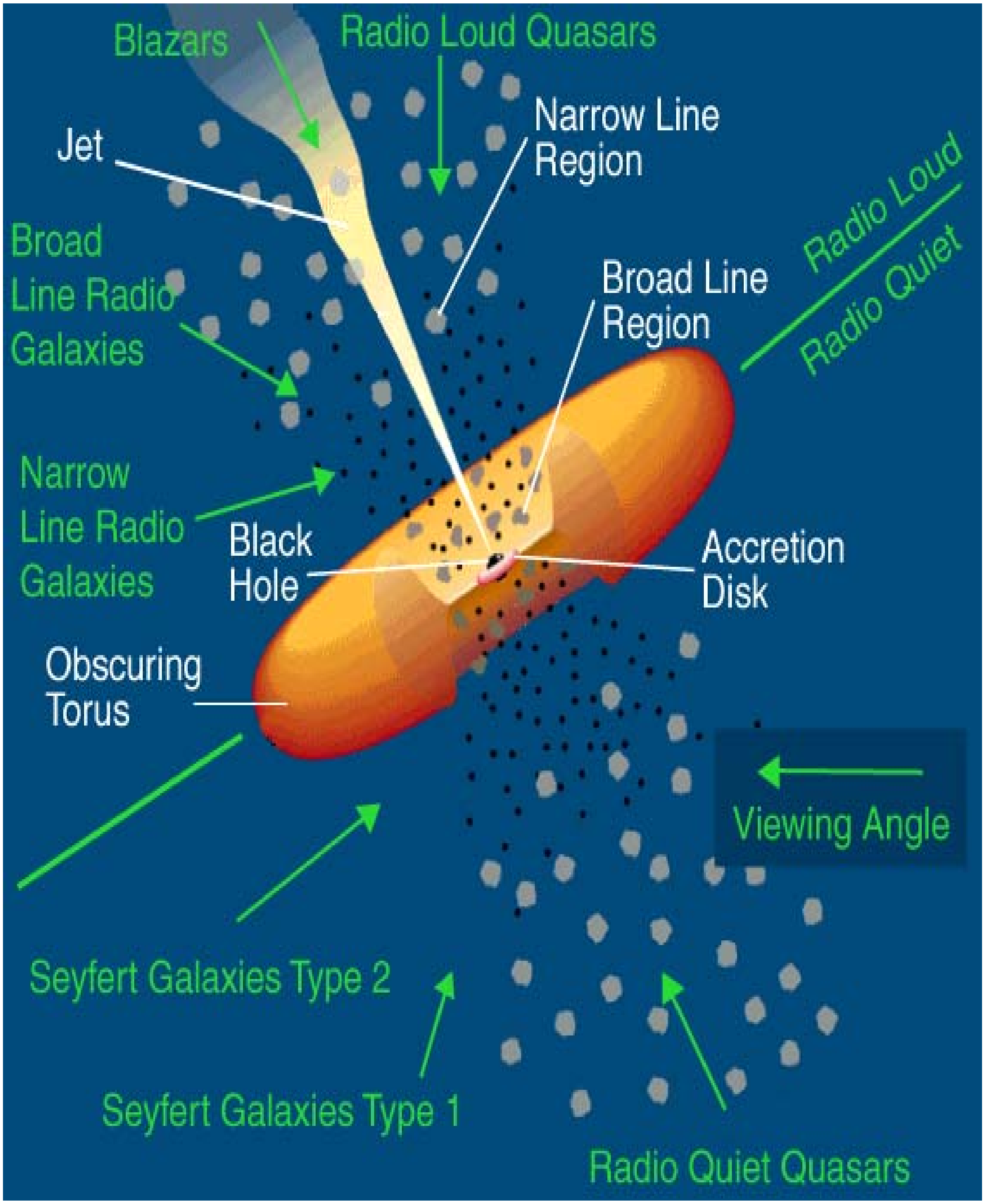


Fig. 18: Schematic illustration of the Unification models of AGN (Urry & Padovani, 1995)

However, it has not been all smooth sailing for the Type-1/Type-2 AGN Unification Models. There are several observations that seem to disagree with the predictions of these Unification schemes.

Among the observations that are inconsistent with the Type-1/Type-2 Unification models are cases in which number of sources' X-rays spectra show no absorption but their optical spectra suggest obscuration (Pappa et al. 2001; Panessa and Bassani, 2002; Barcons et al., 2003; Georgantopoulus and Zezas, 2003; Caccianaga et al, 2004; Corral et al, 2005; Wolter et al 2005; Tozzi et al 2006).

Also, there are inconsistencies with Type-1/Type-2 AGN Unification Model that are complete reverse of the aforementioned examples. For them, their optical spectra show no obscuration but their X-ray spectra suggest absorption (Comastri et al., 2001; Wilkes et al., 2002; Fiore et al., 2003; Brusa et al 2003; Gallagher et al 2006; Wilkes et al 2002; Silverman et al 2005; Hall et al. 2006).

Nevertheless, staunch believers in the Type-1/Type-2 AGN Unification Model have not sat idly and allow these aesthetics schemes go to waste. They have come up with clever arguments and schemes in an attempt to explain away these inconsistencies as mere apparent contradictions, which are not intrinsic to the AGN. Prominent among these scheming is the invocation of observational complications such as: host galaxy dilution (Moran et al, 2005), X-ray variability (Paolillo et al., 2004), the redshifting of broad lines out of the spectral window (silvermann et al 2005), etc. Where observational complications cannot adequately explain away these disagreements, the Unification models are extended to include different kind of obscurations including a clump torus model (Risaliti et al, 2000; Honig et al., 2006; Elitzur, 2007; Nenkova et al., 2008), a torus-as-a-wind models, (Emmering et al, 1997; Kartje et al, 1999), receding torus model (Hatziminaoglou et al., 2009), leaky torus models (Vignali et al., 1997), SMC-like dust (Hopkins et al., 2004), gray dust (Gaskell et al., 2004) etc.

Testing the Unification Models

Paradoxically, the detection of polarized broad emission lines in Seyfert2 galaxies, which motivated the idea of AGN unification, is the major roadblock to full acceptance of this unification schemes.

Detection of polarized broad emission lines (PBL) in the optical spectra of Seyfert2 through spectropolarimetry, which is the best and clearest evidence for the unification models of AGN, stimulates belief in the Unification models. Yet, the very fact that only about 50% of the currently known Seyfert 2 galaxies show the presence of broad emissions lines in their polarized optical spectra (Tran 2001, 2003; Nicastro et al. 2003; Haas et al 2007; Gu & Hwang 2002) throw a spanner into the whole idea of AGN unification.

Despite having lots of time, energies and resources directed to this issue and despite some of the best mind being deployed to tackling it, the nettlesome question of why only about 50% of the currently known Seyfert 2 galaxies show the presence of broad emissions lines in their polarized optical spectra has refused to be convincingly answered.

Lots of techniques and clever tricks have been instituted to ascertain whether the non-appearance of polarized broad emission lines in the optical spectra of some Seyfert 2 lines is truly an intrinsic property or simply consequences of observational complications. Many suppositions as to how the Broad Line Region (BLR) can be absence, could be weak or can fade away thus which accounting for the absence of polarized broad emission lines in the optical spectra of some Seyfert 2, have been propounded (Elitzur and Ho 2009; Elitzur & Shlosman, 2006; Nenkova 2000, Yuan, 2007).

The many radically different interpretations that have been proffered in order to account for the lack of polarized broad emission lines in about half of the known Seyfert 2 galaxies include:

- ❖ The absence or presence of polarized broad emission lines in Seyfert 2 optical spectra is a function of their luminosity, with the presence of broad emission lines in the spectra associated with higher luminosity (Lumsden &Alexander 2001; Gu and Huang 2002; Martocchia & Matt 2002; Tran 2001, 2003, Elitzur & Ho, 2009)

- ❖ The absence or presence of polarized broad emission lines in Seyfert 2 optical spectra is a function of the efficiency of accretion. In situations of low accretion, there is no mean of supporting a broad line region in Seyfert 2 sources (Tran 2001, 2003, Nicastro, Martocchia & Matt 2003, Yuan& Narayan, 2004, Nicastro et al., 2003).

- ❖ Seyfert 2 without polarized broad emission lines could simply be powered by starburst rather than accretion onto an SMBHs (YU & Hwang 2005, Wu et al 2011)

- ❖ Seyfert 2 without polarized broad emission lines would intrinsically lack broad line region (Tran, 2001).

- ❖ Some Seyfert2 galaxies might be deficient in scattering material.

- ❖ The polarized broad emission lines would be diluted by the host galaxy (Moran et al 2002; severgnini et al. 2003; Hasinger et al 2005; Alexander, 2001; Gu et al., 2001)

- ❖ More luminous Seyfert 2 galaxies tend to have large scales height of the scattering region, thus increasing the visibility of the Polarized broad emission lines (Shu et al., 2007; Lumsden & Alexander 2001)

- ❖ Increment in the dust sublimation radius result in the inner surface of the torus being pushed outward from the AGN as luminosity increases (Lawrence, 1991).

- ❖ Some mysterious evolutionary processes that could result in the absence or presence of polarized broad emission lines in Seyfert 2 galaxies would be at work (Tran 2003)

❖ Long term large amplitude variations in the nuclear activity could vary the Polarized Broad emission line flux and thus the detection of the Polarized Broad emission line (Lumsden et al., 2004)

The history of science is replete with situations where the answer to a problem refused to come by because of simply overlooking a somewhat insignificant detail (e.g., the ether and the theory of special relativity). In the spirit of checking little but crucial details before looking at much more complicated details, we are lead by hindsight to think of the possibility that the lack of polarized broad emission lines in some Seyfert 2 galaxies have more to do with poor data than with some intrinsic properties. Probably, with better statistics, good spectral resolution, higher signal- to –noise ratio and better spatially resolved data, a definitive answer as to whether all Seyfert 2 galaxies contain a Seyfert 1 nucleus and that the lack of polarized broad emission lines in about 50% of Seyfert 2 galaxies has nothing to do with the lack of Broad Line Regions could be answered.

Since Seyfert galaxies are nearby and bright enough to offer high quality spectra and because there is a chance of getting good resolution of their host galaxies, Seyfert galaxies are the ideal choices for testing the Type-1/Type-2 Unification model. Lots of researchers have done just that.

Of all the magnificent works done using Seyfert galaxies to test the AGN unification models, we chose Shu et al.' 'Investigating The Nuclear Obscuration in Two Types of Seyfert 2 Galaxies' (Shu et al., 2007) as the prototype for this thesis because it resonates very well with the overall objectives of this thesis.

In that seminal work, Shu et al. demonstrated vividly that comparatively luminous sources (Seyfert 2 with luminosity $>10^{41}$ergs^{-1}) without polarized broad emission lines (NPBL) in their optical spectra have higher obscuration than those with polarized broad emission lines (PBL). Their conclusion tied in neatly with the torus structure propounded by Heisler et al. (1997), which hypothesizes that the main electron scattering is confined to a conical region that is close to the thickness of the torus. So, "more inclined Seyfert 2 sources would have the broad line scattering screen also obscured, thus making PBLs weaker or non-detectable." According to the unified model, more inclined sources are expected to have heavier obscuration, thus explaining the differences in obscuration between PBLs and NPBLs" (Shu et al., 2007).

Shu et al.'s conclusions included the appetizing generalization "while extended obscuration from the host galaxy might explain the absence of PBLs in some sources, it could not be the major cause, or else we should have a large number of NPBL Seyfert 2s among the luminous Seyfert 2s with $N_H < 10^{23.8}$ cm^{-2}.

The nagging question that will come fluttering into the mind of any keen reader of Shu et al.'s work is why were the comparatively low luminous sources (Seyfert 2 with luminosity $<10^{41}$ergs^{-}) left out their conclusions despite these sources being interwoven in the overall analysis?

A closer look at their work and one quickly see that, not only are the comparatively low luminous sources (Seyfert 2 with luminosity $< 10^{41}$ergs^{-}) not included into Shu et al.'s conclusions, they are inconsistent with the very Heisler et al., 2007 favor of the Unification Models which the luminous of Shu et al.'s sample seem to be in accordance with.

Several comparatively low luminous sources (Seyfert 2 with luminosity $< 10^{41}$ergs^{-}) among Shu et al.'s sample (e.g., NGC 750, NGC 4501, NGC 3660, NGC 1358, etc see Table 1 of Shu et al., 2007 for details) are not heavily inclined/ obscured (have $N_H < 10^{24}$ cm^{-2}) and going by the torus geometry portrayed by Heisler et al., 1997 which formed the fulcrum for Shu et al.'s explanations for their observations and interesting generalization (while extended obscuration from the host galaxy might explain the absence of PBLs in some sources, it could not be the major cause, or else we should have a large number of NPBL Seyfert 2s among the luminous Seyfert 2s with $N_H < 10^{23.8}$ cm$^{-)}$, then these less inclined sources ought to have polarized broad emission lines.

Someone would natively argue that Shu et al.'s work, rather than out ruling the host galaxy as a major contributor to the lack of polarized broad emission lines in Seyfert 2, it demonstrates just that. The person would argue that it is the dilution from the host galaxy that account for the less luminous but not heavily inclined sources of Shu et al.'s sample not showing PBLs.

Without an extension, the implications of Shu et al.'s work for the Unification models, at best, is inconclusive, at worst, amount to cherry-picking the evidences to support the Unification models.

This thesis is intended to extend Shu et al.'s work. Our aim is to see if the comparatively low luminous sources (Seyfert 2 with luminosity $<10^{41}$ergs^{-}) can be incorporate into Shu et al.'s conclusions and in so doing remove all ambiguities associated with the non-inclusiveness of their conclusions and hopefully disabuse any discombobulating impression that might arise from the inconclusiveness of Shu et al.'s work.

Out of intuition, we suspect that the failure of the comparatively low luminous sources (Seyfert 2 with luminosity < 1041ergs^{-1}) to be in harmony with Shu et al.'s conclusions is due to poor data. So, we will check for new data for these low luminous sources, reduced them when necessary and then follow the same procedures used by Shu et al., 2007.

Chapter 3

Data, Notes, Plots, Tables and Analyses

Data Collection

Given that this thesis is a sequel to Shu et al ‘Investigating The Nuclear Obscuration in Two Types of Seyfert 2 Galaxies’ (Shu et al., 2007), we will collect all the low luminous Seyfert 2 galaxies from Shu et al., 2007 and then checked NASA’s High Energy Astrophysics Science Archive Center (HEASARC), ESA’s XMM-Newton Archive (XSA) and current literatures (2007-2011) for new X-ray data for these low luminous Seyfert 2 galaxies.

Tables (table 1 with the old data and table2 with sources that have new data) are constructed. In these tables, (1) and (2) are the names and redshifts, z, respectively of the galaxies as reported in **NASA**/IPAC Extragalactic Database (**NED**); (3) is the spectropolarimetric properties of the galaxies; (4) is the extinction-corrected flux of the [OIII] emission in units of 10^{-12}ergs^{-1}cm^{-2}, and (5) is the luminosity of the extinction-corrected [OIII]$_{\lambda 5007}$ emission in units of 10^{-12}erg^{s-1}; (6) is the observed hard X-ray (2-10 keV) flux in units of 10^{-12}ergcm^{-2}s^{-1} ; (7) is the X-ray column density for hydrogen, N_H; (8) is the equivalent width (EW) of the fluorescence iron line in units eV.

The Luminosity for the corrected [OIII] λ500 emission is given by

$L\,[OIII]_{corr} = 4\,\pi D\,F[OIII]^{corr}$

Where the $F[OIII]^{corr}$ is given by the relation

$$F^{\rm cor}_{\rm [O\ III]} = F^{\rm obs}_{\rm [O\ III]}\left(\frac{({\rm H}_\alpha/{\rm H}_\beta)_{\rm obs}}{({\rm H}_\alpha/{\rm H}_\beta)_0}\right)^{2.94}$$

The Balmer decrement (H_α/H_β) = 3.0(please see Shu et al., 2007 for the nitty gritty of the table and how the data were selected).

Table 1. OPTICAL AND HARD X-RAY DATA FOR SEYFERT 2 GALAXIES WITH/OUT PBL

Name (1)	z (2)	PBL? (3)	$F_{\lambda 5007}$ (4)	$L_{[O\ III]}$ (5)	$F_{2-10\ keV}$ (6)	$\log_{10} N_H$ (7)	EW(Fe) (8)
NGC 5194	0.0015	n	2.2	40.03	0.48	24.748	986^{+210}_{-210}
NGC 3079	0.0038	n	0.92	40.47	0.33	25	1480^{+500}_{-500}
NGC 3660	0.0123	n	0.17	40.76	2.22	20.26	...
NGC 3982	0.0037	n	0.66	40.3	0.057	> 24	6310^{+3500}_{-3170}
NGC 4501	0.0076	n	0.06	39.89	0.11	< 21.03	...
NGC 5283	0.0104	n	0.4	40.98	1.46	23.176	<220
NGC 5695	0.014	n	0.081	40.55	<0.01	...	...
NGC 6890	0.0081	n	0.5	40.86	...	...	...
NGC 7172	0.0087	n	0.04	39.83	22	22.95	40 ± 30
NGC 788	0.0136	y	0.15	40.79	4.62	23.324	...
NGC 1358	0.0134	n	0.18	40.86	0.86	23.6	...
NGC 3982	0.0037	n	0.66	40.3	0.057	> 24	6310^{+3500}_{3170}
NGC 5283	0.0104	n	0.4	40.98	1.46	23.176	<220
NGC 5929*	0.0083	y	1.53	41.40	1.35	22.629	...
NGC 6890	0.0081	n	0.5	40.86	...	...	...
IRAS 04385-0828	0.0151	y	0.086	40.64	2.4	...	...
NGC 7496	0.005	n	0.3	40.22	<8	22.699	...
Circinus	0.0014	y	19.1	40.92	17	24.633	2250^{+260}_{-300}
NGC 6300	0.0037	n	3.2	40.99	21.6	23.342	148^{+18}_{-18}
NGC 7590	0.0053	n	0.168	40.02	1.2	<20.964	...

Note: see shu et al., 2007 for references.

Table 2. UPDATED OPTICAL AND HARD X-RAY DATA FOR SEYFERT 2 GALAXIES WITH/OUT PBL

Name (1)	z (2)	PBL? (3)	$F_{\lambda 5007}$ (4)	$L_{[O\ III]}$ (5)	$F_{2-10\ keV}$ (6)	$\log_{10} N_H$ (7)	EW(Fe) (8)	(9)	References
NGC 788	0.0136	y	0.15	40.79	41	3.0	$23.968^{+0.019}_{-0.019}$	250^{+250}_{-95}	1
NGC 1358	0.0134	n	0.18	40.86	43	0.23	> 24	$1.08^{+0.4}_{-0.4}$	1
NGC 3660	0.0123	n	0.17	40.76	27,61	2.86	<20.38	...	1
NGC 4501	0.0076	n	0.06	39.89	31	0.081	> 24	...	2
NGC 5695	0.014	n	0.081	40.55	22	<0.054	>24	...	4
NGC 6890	0.0081	n	0.5	40.86	43	0.069	>24	...	3
NGC 7590	0.0053	n	0.168	40.02	27	0.016	>24	<2000	5

Note. — The Sy2s with footnote * denote the PBL was detected in later spectropolarimetric observation. Telescope: C = CTIO (4m), P = Palomar (5m), K = Keck (10m), L = Lick (3m), S = Subaru (8.2m), E = ESO (3.6m), A = AAT (3.9m).

References. — (1) from Data fitting; (2) Brightman & Nandra 2008; (3) Shu et al. 2008; (5) Shu et al. 2010; (4) Lamassa et al. 2009.

Notes on Individual Sources

From NASA's High Energy Astrophysics Science Archive Center (HEASARC), ESA's XMM-Newton Archive (XSA) and current literatures (2007-2011), we found out that seven of our sources (NGC 788, NGC 1358, NGC 3660, NGC 4501, NGC 5695, NGC 6890 and NGC 7590) have new data. While NGC 4501, NGC 5695, NGC 6890 and NGC 7590 have already been reduced and analyzed elsewhere; we ourselves had to reduce and analyze the data for NGC 788, NGC 1358, and NGC 3660.

The model used for the reduction and analyses of the NGC 788, NGC 1358, NGC 3660 data was a simple absorbed power law plus a soft blackbody component, where necessary.

NGC 3660

From ASCA Tartarus (tartarus.gsfc.nasa.gov), Shu et al., (2007) found this low luminous Seyfert galaxy to have is an observed hard X-ray flux, $F_{2\text{-}10keV}$ of 2.22 $\times 10^{-12}$ erg.cm^{-2}.s^{-1} and a hydrogen column density less than 10^{21} cm^{-2}.

Spectral fitting NGC 3660 current data with a simple absorbed power law (with photon index Γ= 2.0±0.03, intrinsic NH < 2.4 $\times 10^{20}$ cm^{-2} and observed $F_{2\text{-}10keV}$ of 2.86 $\times 10^{-12}$ erg.cm^{-2}.s^{-1}) plus a soft blackbody component (T= 0.07 kev) and a narrow emission line at 6.25±0.05 keV with an EW of 130± 65 eV.

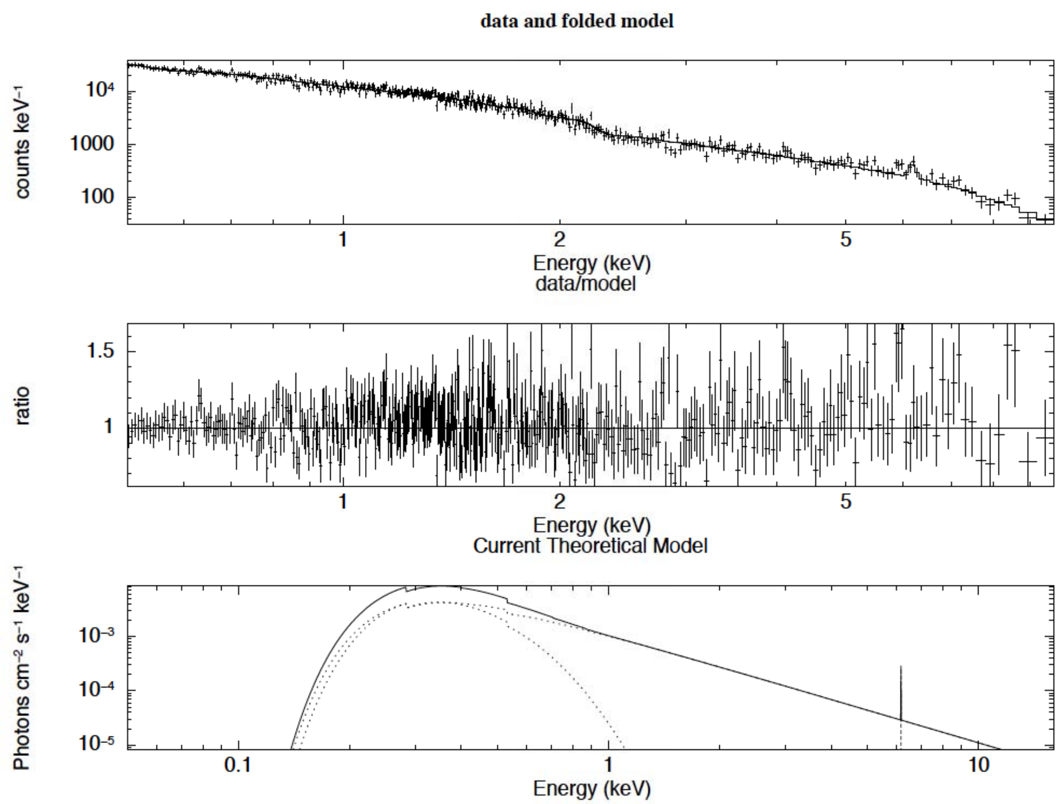


Fig. 19: XMM PN spectrum of NGC 3660. The data was obtained on 06/03/2009 with a net exposure time of 14.7 ks.

Shi et al., 2010, later identified NGC 3660 as a type-1 object based on archival spectrum. Since this work is dealing with only Type-2 objects, nothing more will be said about this source.

NGC788

Also from ASCA Tartarus (tartarus.gsfc.nasa.gov), Shu et al., 2007 found NCG 788 to be heavily obscured (with $N_H = 23.32 \times 10^{23}\ cm^{-2}$) and with an observed rest-frame hard X-ray flux, $F_{2\text{-}10kev}$ of 4.62×10^{-12} erg.cm^{-2}.s^{-1} and there are little changes in the situation when current data for this source is considered.

From spectral fitting to new XMM PN spectrum, we measured an hydrogen column density of (93±4)$\times 10^{22}$ cm^{-2} and rest-frame fluxes $F_{2\text{-}10keV}$= 3.0$\times 10^{-12}$ erg.cm^{-2}.s^{-1} and $F_{0.5\text{-}2keV}$= 1.47$\times 10^{-13}$ erg.cm^{-2}.s^{-1}. The observed Fe Kα line EW is 250 $^{+250}_{-95}$ eV.

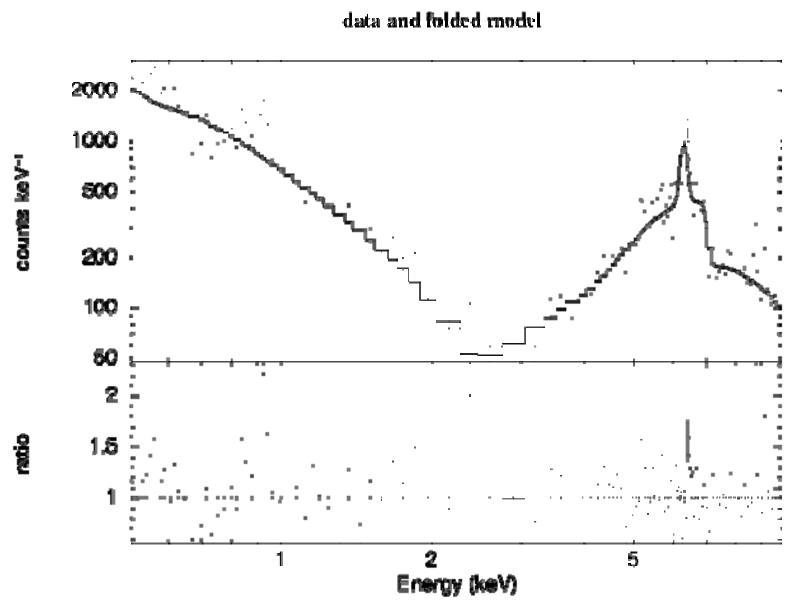


Fig. 20: XMM PN spectrum of NGC 788. The data was obtained on 01/15/2010 with a net exposure time of 35.4 ks.

NGC 1358

Shu et al. (2007) found from the analysis of Fraquelli et al. (2003) that NGC 1358 has rest-frame hard X-ray flux, $F_{2\text{-}10keV}$ of 0.86 $\times 10^{-12}$ erg.cm^{-2}.s^{-1} and a hydrogen column density logN_H = 23.6 but from latest and better resolved date we get a completely different picture.

From our data reduction, we obtained observed hard X-ray fluxes, $F_{2\text{-}10keV}$ of 2.3×10^{-13} erg.cm^{-2}.s^{-1} and $F_{0.5\text{-}2kev}$= 6.0×10^{-14} erg.cm^{-2}.s^{-1} .

Based on the large Fe Kα line Equivalent Width (EW = 1.08±0.47 keV) and flat spectrum in the hard band, we re-classified this source as Compton-thick ($N_H > 10^{24}$ cm^{-2}).

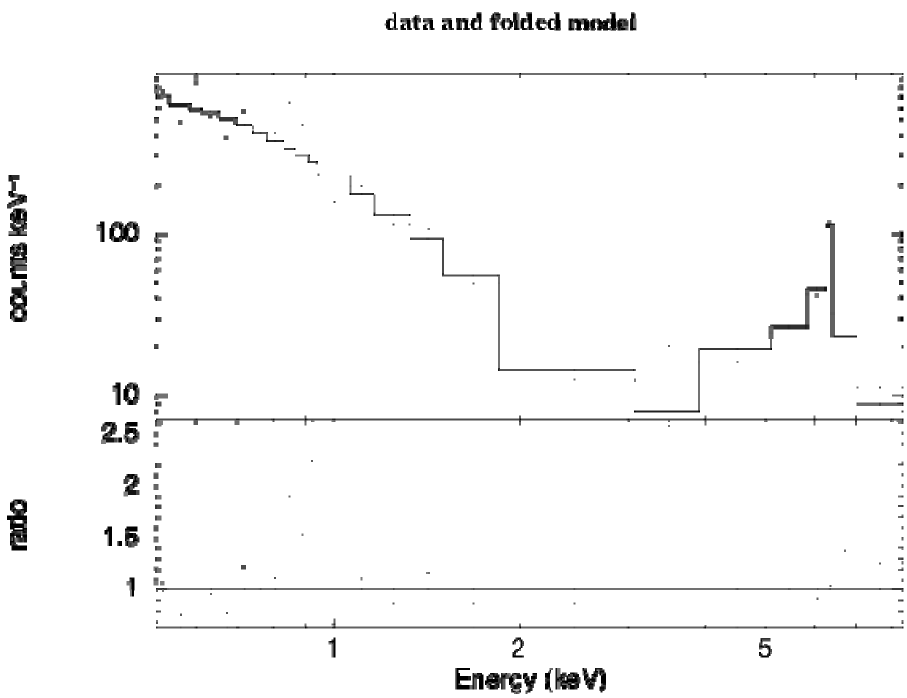


Fig. 21: XMM PN spectrum of NGC 1358. The data was obtained on 08/30/2005 with a net exposure time of 12.7 ks.

NGC 4501

Shu et al. (2007) reduced data for this source, which was obtained from Cappi et al. (2006), classified this source as Compton thin ($\log N_H < 21.03$) with an intrinsic hard X-ray flux of $F_{2\text{-}10keV} = 0.11 \times 10^{-12}$ erg.cm^{-2}.s^{-1} but the completely opposite picture emerges when reduced and analyzed data of this source from Brightmann & Nandra (2008) is considered.

Using Chandra image which has much better spatial resolution than previous X-ray images on this source, Brightmann & Nandra (2008) shows this source to be heavily obscured in the X-ray regime ($logN_H > 24$) and with an intrinsic hard X-ray flux of $F_{2-10kev} = 0.081 \times 10^{-12}$ erg.cm^{-2}.s^{-1}. They attributed the unabsorbed nature portrayed by the old data as being due to contamination from the host galaxy.

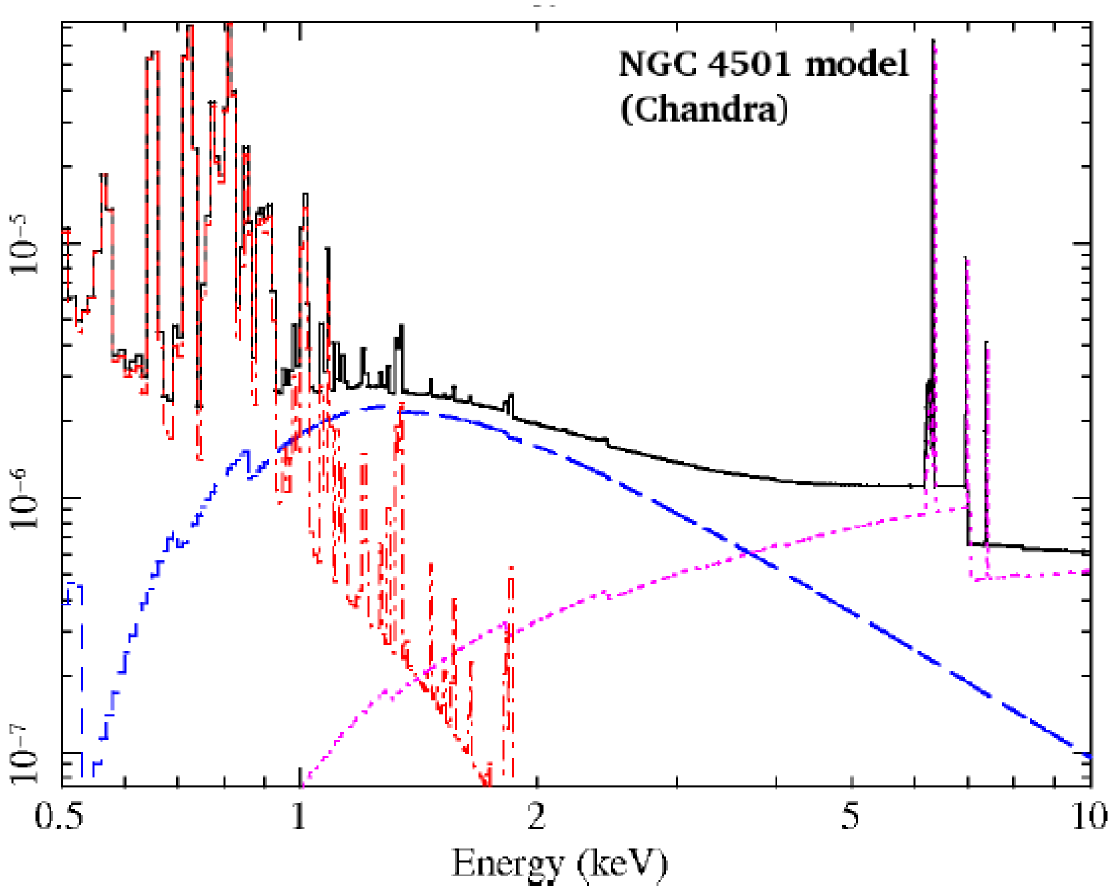


Fig. 22: In the plots of the best fit model, blue dashed lines represent the unabsorbed power-law, red dot-dashed represent the thermal component if present, and the magenta dotted lines represent the reflection or transmitted component if present (Brightmann & Nandra)

NGC 5695

The old X-ray data for NGC 5695, taken from Polletta et al. (1996) by Shu et al. 2007, is very scanty. It has neither a column density nor Equivalent Width but an intrinsic hard X-ray flux of $F_{2-10keV} < 0.01 \times 10^{-12}$ erg.cm^{-2}.s^{-1}.

With recent data, Lamassa et al. (2009) identified this source as Compton thick ($\log N_H > 24$). From spectral fitting, Lamassa et al. (2009) found that the best-fit spectra for this source, using single absorbed power law, give $F_{2\text{-}10kev} < 0.054 \times 10^{-12}$ erg.cm^{-2}.s^{-1}.

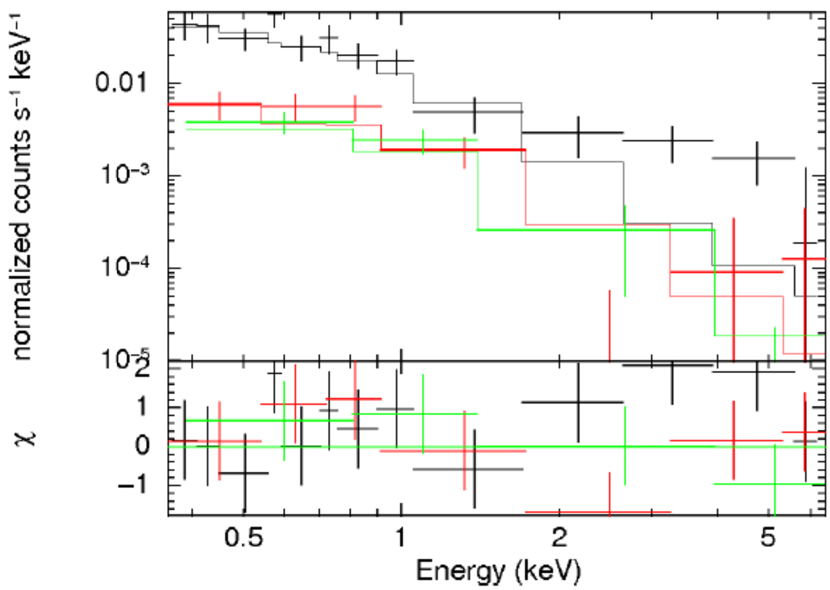


Fig. 23: Best-fit spectra for NGC 5695 using single absorbed power law (Lamassa et al., 2009

NGC 6890

With the availability of new XMM data on this source, Shu et al. (2008) critically analyzed this source and found it to be Compton thick in the X-ray band ($\log N_H > 24$) and with an intrinsic hard X-ray flux, $F_{2\text{-}10keV} = 0.069 \times 10^{-12}$ erg.cm^{-2}.s^{-1}.

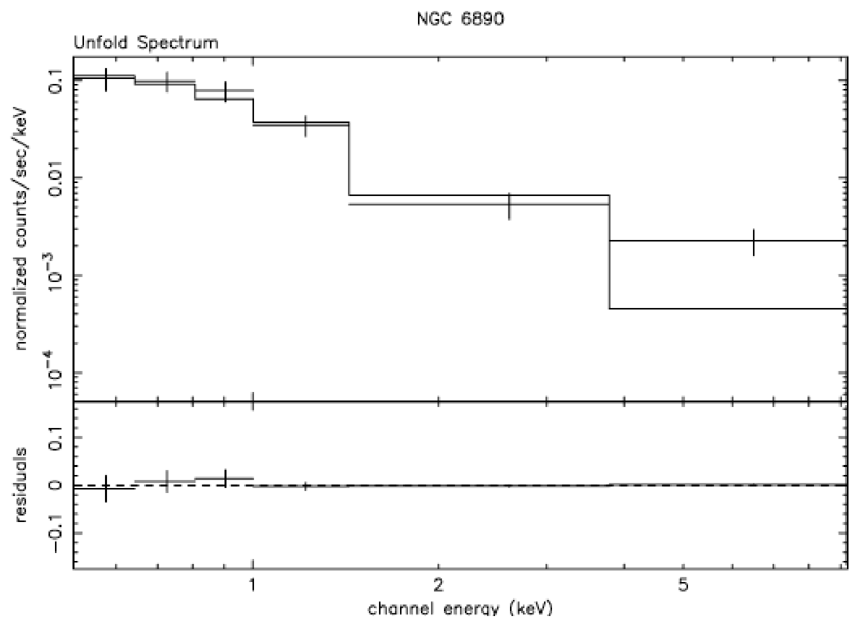


Fig. 24: XMM-Newton PN spectra for NGC 6890 (Shu et al. 2008).

NGC 7590

Shu et al. (2007) found from the analysis of Bassani et al., 1999 that NGC 7590 has rest-frame hard X-ray flux, $F_{2\text{-}10keV} = 1.2 \times 10^{-12}$ erg.cm^{-2}.s^{-1} and a hydrogen column density $\log N_H < 20.964$.

A completely different picture emerged when Shu et al., (2010) re-examined this object with new X-ray data. They found out that this source is Compton thick in the X-ray band ($\log N_H > 24$) and with $F_{2\text{-}10\ keV} = 0.016 \times 10^{-12}$ erg.cm^{-2}.s^{-1} .

Plots and Tables

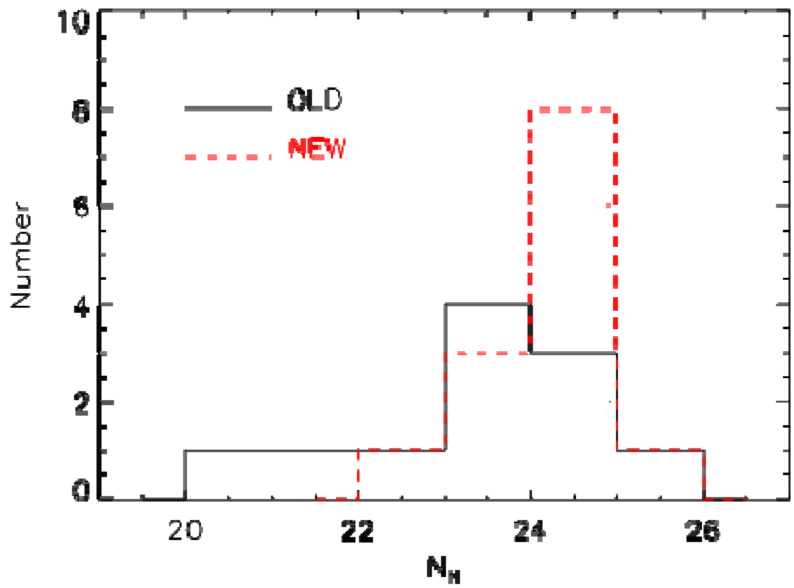


Fig.25: The distribution of N_H of the low luminous Seyfert 2 sources (Log_{10}[OIII]< 41) for both old and new data.

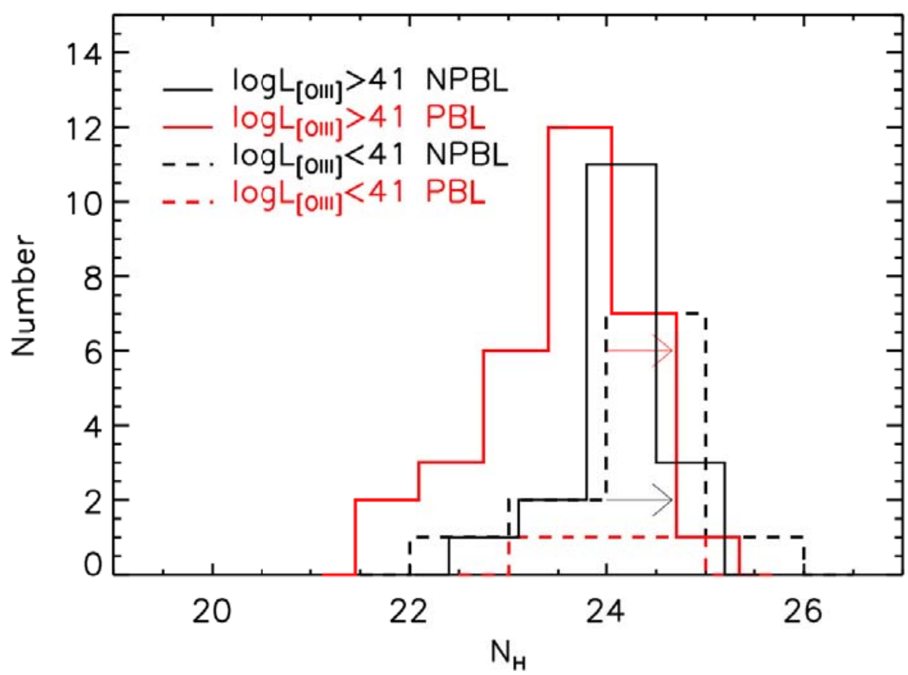


Fig. 26: Plot of all the samples from Shu et al. 2007 together with updated data, where applicable

Discussions and Explanations

In figure 25, we plotted the N_H distributions for all the low luminous Seyfert 2 sources from our data using both old and new data.

A Kolmogorov- Smirno (K-S) test of the column densities of our old and new data shows a significant difference of 0.08 between the two distributions, which translates into 92% probability that the two distributions are difference. Figure 25 vividly shows this huge difference between the two distributions.

We see that the new X-ray data for low luminosity Seyfert 2 galaxies without polarized broad emission lines show higher column densities than the old X-ray data for the same sources. The implication of plot 25 is that most of the low luminosity Seyfert 2 galaxies without polarized broad emission lines in Shu et al., 2007's sample have high column densities along the line of sight. This neatly incorporate the low luminosity Seyfert 2 sources of Shu et al., 2007's sample into their conclusion that Seyfert 2 sources "without polarized broad emission have higher obscurations than those with polarized broad emission lines."

From Figure 26, we see that the histogram of the high luminous NPBL sources (LogL[OIII] > 41), represented by the solid black line and those of the low luminous from sources (LogL[OIII] <41), with updated data where necessary, show similar patterns.

The Kolomogoro- Smirno (K-S) test of the high PBL sources and the low NPBL sources distributions indicates a 96.3% probability of the distributions being different, which increases marginally to 97.7 % when the amount of luminosity is disregarded.

The implication of the plots in Figure 26 is that Seyfert 2 sources from Shu et al., 2007's sample with polarized broad emission line shows lower column densities than those without polarized broad emission line. This dovetailed in neatly with Shu et al., 2007 conclusions.

In short, the availability of higher signal-to-noise and better spatially resolved data has enable us to neatly incorporate the comparatively low luminous of Shu et al.'s sample into their conclusion thus reinforcing confidence in the Unification models of AGN.

Chapter 4

Conclusions

Conclusions

In this thesis, we have seen that attempts have been made to use very few parameters like orientation to account for the vast diversities among the Active Galactic Nuclei. We saw that though these attempts (called the Unification models) have been largely successful, there are observations that defied them.

We saw that according to the Type-1/Type-2 Unification Model, spectropolarimetric analysis of Seyfert should show polarized broad emission lines in their optical spectra but why only about 50% of Seyfert 2 shows polarized broad emission lines in their optical spectra is a subject of serious investigation.

We discussed that Shu et al. (2007) undertook the daunting task of solving this riddle. Though, Shu et al. (2007) could only provide half answer, their work provided great insights into the problem and possible solutions.

Our task was to build upon their insights and, in doing so, provide the full answer. We did that successfully by intuitively suspecting that the low luminous Seyfert 2 sources in Shu et al., 2007 sample couldn't be incorporated into their work because the data for those low luminous sources were too poor. With much better data, we succeeded in harmonizing almost all of their sources with their conclusions.

Suggestions

Having successfully done the task we set for ourselves, we now pause, reflect on our work; see what lessons we have learned, and the implications of our work for the AGN Unification schemes.

What are the overall goals of AGN Unification models? Can higher signal-to-noise ratio, better spatial resolved data and better statistics solve all the problems afflicting the Unification models of AGN? Even in principle or theory, is full spatial resolution of the inner structures of AGN possible? How ironclad are the evidences for the existence of Black Holes? Can the current trends in AGN researches ever succeed in eliminating all of the inaccuracies and inconsistencies associated with the Unification models? How testable are models for which there are too many free parameters and how many unknowns? What are the predictive and explanatory powers of theories and models of very complex phenomena (particularly AGN) drew from phenomenology?

These are few of the myriads of questions that came fluttering into our mind as we pondered over the implications of the procedures used to comprehensively solve the question of the lack of broad emission lines in some Seyfert 2 galaxies.

Hints to the answers to the aforementioned questions would come from the following poignant observations that have eluded explanations:

- ❖ The optical spectra of some AGN have been known to change between types, say Seyfert 1 to Seyfert and vice versa (Penston & Perez, 1984; Aretxaga et al., 1999) or from LINERs to Seyfert 1 (Storchi-Bergmann, Baldwin & Wilson, 1993; Bower et al, 1996; Kording, Jester & Fender, 2006).

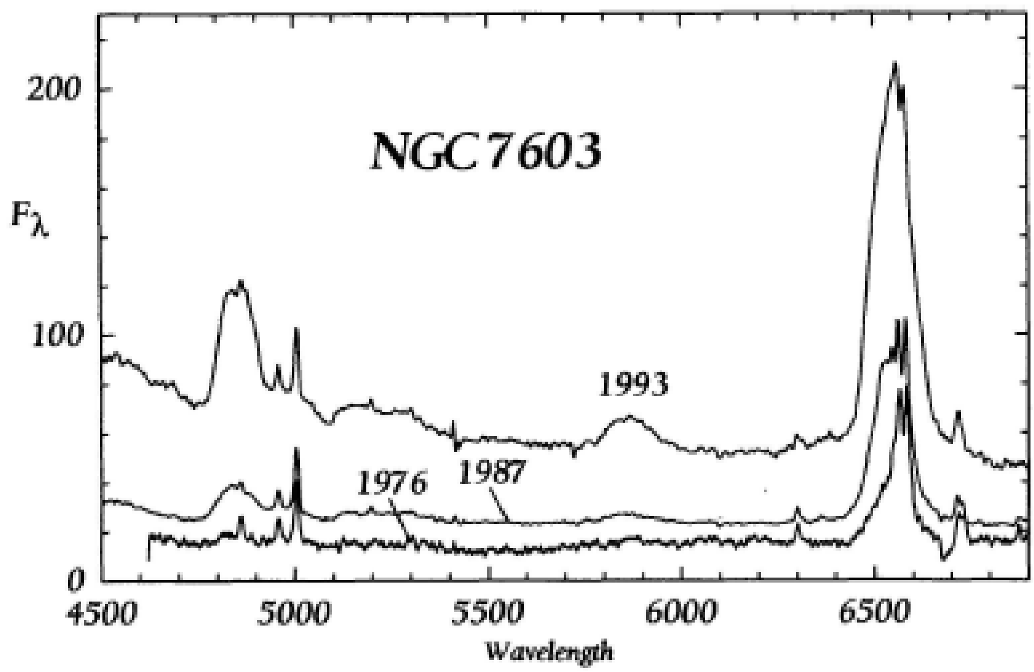


Fig. 27 NGC 7603 changing type within a few years

- There are evidences that Seyfert 1 and Seyfert 2 have different radio brightness (Roy et al., 1994)

- The UV spectra of Seyfert 2 galaxies have approximately the same shape as the UV spectra of Seyfert1 (Kinney et al. 1991).

- The featureless continuum in Seyfert 2 still look more or less a power law which shouldn't be if in fact it is heavily reddened; a reddened power law is no longer a power law

- The slope of the intrinsic continuum X-ray emission is slightly harder in Seyfert 2s than in Seyfert 1s (Beckmann et al. 2006; Malizia et al. 2003; Zdziarski et al. 1995).

- Insights could also come from the observations that AGN Unification Models fail to explain the following:

- Why the continua in Seyfert 2 are suppressed by only a magnitude or so, but the broad lines emission can be completely extinguished？

- Why Seyfert1 is preferentially hosted in galaxies of earlier Hubble type (Malkan et al 1998)?

- Continuum polarization is expected to reach 50% for an edge -on system (Miller and Goodrich, 1990). Why are there not any known Seyfert 2 sources with very high-polarization?

- If the electron temperatures are truly different in the coronas of Seyfert 1 and Seyfert 2 then their magnetic fields might be different. What in the unified model can account for a different in magnetic fields between type-1 and type-2 objects?

- Why low-luminosity radio-loud AGNs produce weaker or no emission lines (Hine & Longgair, 1997; Jackson & Rawlings, 1997)? Lack the dusty infrared emission (Ogle et al., 2006)? And accretion related X-ray emission (Hardcastle et al., 2006)?

- ❖ What are the explanations for the supporting mechanism that maintain the thickness of the torus and the geometry of the dust?

- ❖ Why there are Significant increases in the fraction of type 2 with redshifts (Hasinger 2008; Treister et al 2010)?

- ❖ What is the origin of the difference between Seyfert 1 and Seyfert 2?

- ❖ Why does Seyfert 2 have a higher propensity for nuclear starbursts (Buchanan et al 2006)?

- ❖ What are the explanations for the origin of the magnetic fields found in active galaxies?

- ❖ How do the accretion disk and the corona coupled?

- ❖ What supporting mechanisms maintain the thickness of the torus?

- ❖ Which processes form the corona? What are the compositions of the corona? Where is the corona located?

- ❖ Where does the X-ray variability in Seyfert 1 come from?

- ❖ What are the origins of the high-energy emission of Blazars?

- ❖ How did the initial Black Hole form and how did it become Supermassive?

- ❖ Which events triggers AGN phenomena and which conditions cause them to switch off?

Despite the Unification Models of AGN being around for decades and some of the best brains and minds being deployed to patch up the Contradictions, inconsistencies and inaccuracies associated with them, answers to the aforementioned observations and questions remain elusive as ever before.

In fact, one can say, without a shadow of doubt, that our understanding of the physical phenomena associated with AGN has retrogressed with the availability of multi-frequency observations. It seems like the more information about AGN we get, the more inconsistencies with the predictions of the Unified Models surface.

Thus, it raises the question, what is the real significant of the unification models of AGN? Are the Unification schemes of Active Galactic Nuclei merely convenient means of labeling or classification phenomena one have very little knowledge about?

With too many free parameters and limitless unknown variables, it seems like the only prerequisite to establishing or making an AGN model stand is a rich vein of imagination. This has resulted in the notoriety of conflicting the theses and the antitheses on AGN but yet coming up with syntheses prevalent in AGN endeavors.

We submit that something serious awry with the methods and procedures use in deriving conclusions about AGN phenomena. Current trends in understanding AGN are analogous to the "six blind men and the elephant". [6] Just as those six legendary blind men experienced, phenomenological approaches can only give piecemeal information. To get full understand of the intriguing phenomena occurring in AGN, one needs a global view.

We submit that only a paradigm shift from phenomenological approaches to approaches (i.e., dealing with fundamental quantities and universally invariant quantities) will result in the attainment of a true unified model, which in turn would lead to physical insights, and understanding of what active Galactic Nuclei truly are.

We suggest that the light crossing time arguments (based on the Principle of Causality), the calibrations of galactic distances (based on standard candles) and the existence of Black Holes (especially Supermassive Black Holes), firm and stout as they seem, need to be subjected to critical re-examination if we are ever to have panoramic views of AGN.

The relatively small angular size of an AGN is largely based on simple geometry and light crossing arguments. It is firmly believed that any other explanations for the rapid variations of the radiations from AGN (which can be on timescales as short as minutes) other than that the radiations are coming from relatively small regions violate one of the most cherished of all physical principles, the Principle of Causality (cause must precede its effect according to all inertial observers or no information carrying phenomena can travel faster than the speed of light. The light crossing arguments have resulted in the ruling out of alternative sources such as Neutron stars, heavy fermions, sterile neutrinos, gravitinos or axions, boson stars etc. (Tsiklauri and Viollier, 1998; Genzel et al., 2000; Schodel et al., 2003), as engines for AGN.

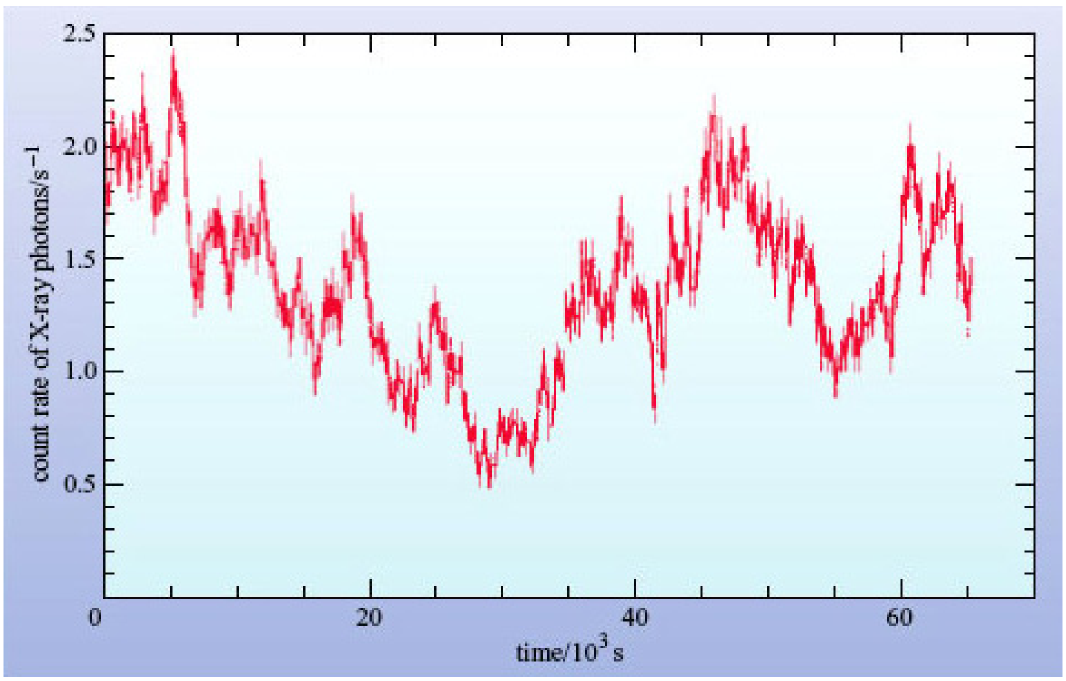


Fig. 28: X-ray variability shown by MCG-6-30-15 during observation by Chandra (Lee, J.S. et al., 2002)

It is conceivable that the rapid variability of AGN radiations could be intrinsic. That is, the region from which the radiations are coming from would have been set up from initial conditions to do similar things at nearly the same time and in similar pattern independent of each other. In other words, different regions would simply be obeying principles they were set up to obey rather than them be responding to causes occurring at a particular place.

With intrinsic variations, the lights crossing arguments and their implications for the Principle of Causality become a non-issue. The same processes that are responsible for the coronas and jets in AGN would as well set up internal memory in causally disconnected regions which would cause them to responsible in ways that seem to violate Principle of Causality. A good example to illustrate this is a person reading a text to his friend but his friend already know the text, the friend can say it without waiting to hear the readers' voice. To the third observer such situation looks like faster than light communication (Schiller, 2005).

Intrinsic variation is a possibility because:

There is no physical principle that forbids it. As the maxim goes; everything that is not forbidden is compulsory.

The casimir effect and neutrino oscillations are two examples that nature does unusual things under extreme circumstances. Considering that the processes occurring in AGN are highly unusual, there is no reason why Magnetic phenomena serving as memory engine couldn't be a possibility.

By playing with the topology of the magnetic field, the hotly contested issues of discordant redshifts/ intrinsic redshifts (e.g., Stephan's Quintet, NGC 4319, and NGC 7603), Synchrotron catastrophe and magnetic monopole can all be comfortably explained by intrinsic variations.

The aforementioned would only be ruled out if the magnetic processes in AGN were fully understood. Unfortunately, magnetic phenomena are among the least understood of all physical processes. Therefore, we suggest that great emphasis be placed on understanding the origin, structure and evolution of magnetic phenomena in AGN.

Another peculiarity of Active Galactic Nuclei is that they are very far away. For example, quasars have been discovered, astonishing, at redshifts, $z > 6$ (Fan et al 2006; Jiang et al 2008; Willot et al 2010). Consequently, the very fact that they are seen at all implies that they are extremely luminous.

The whole schemes of galactic and extra-galactic distance measurements are hinged on a ladder system (the cosmic distance ladder), which includes parallax, and standard candles. A flaw in any rung of the cosmic ladder brings the whole system crashing like deck of cards.

Also, it well established in stellar physics that the luminosity of a star is a function of its mass yet our understanding of the origin and evolution of mass is very rudimentary, to say the least. Besides, it is an established fact that the mass distribution of stars in our galaxy depends on the way the galaxy was formed yet our understanding of the formation and evolution of galaxies, at best, is very poor.

The entire cosmic distance ladder system is analogous to an alien trying understanding the behaviors of children by observing the behaviors of adults without the slightest knowledge of behavior changes or modifications that occurred between childhood and adulthood. So, just as the behaviors of adults is not the true reflection of the behaviors of children, the mass distribution of active stars in our galaxy or nearby galaxies could not be true representation of what is happening in a distant young galaxy.

So, without good understanding of how masses and their distribution evolve with time, we can never be certain about the correctness of cosmic distances. Thus, I suggest that more emphasis be placed on understanding the origin, structure, composition and evolution of galaxies or better still, direct means of measuring cosmic distances (e.g., a theory on Quantum gravity) must be vigorously sought after.

Finally is Black Hole. Black hole is purported to be the amphitheater of AGN activities. Belief in its existence or physical reality is so entrenched in scientific folklore that any attempt to question its existence or physical reality is seen as a sacrilege.

Reading scientific literatures on Black hole or listening to renowned and highly respected scientists talk about Black hole, one leaves with the impression that there are ironclad evidences for the existence or physical reality of Black Hole. When these so-called evidences for existence of Black Hole are closely look at and critically scrutinized, one quickly see that they are simply begging the questions (*petitio principii)* for the existence of Black hole and that, in actuality, the only real argument for the existence of Black Hole is that is that nothing else can produce the puzzling phenomena occurring in AGN. Even this argument has been seriously diluted by proposition of the existence of Dark energy star, the so-called gravaster that mimic black hole (Mazur & Mottola, 2004) with the added advantage of no need for (the nonsensical things called) singularity and event horizon.

We submit that the ingrained notion that a Supermassive Black Hole must power Active Galactic Nuclei is a drawback to progress in understanding the global properties of AGN and we suggest other alternatives should be given their days in court. The arguments for our suggestions are simple and straightforward:

- ❖ The validation of any of our first two suggestions renders the need for Supermassive Black Holes as the engine of AGN irrelevant.
- ❖ The discovery of quasars as far as z > 6 implies that Black Holes with masses greater than 10^7 solar mass were already in place when the Universe was less than one billion years old (Fan, Carilli & Keating 2006). This put the existence of Supermassive Black Holes in such an early universe in direct conflict with the widely accept bottom-up, hierarchical structure formation model of standard cosmology.
- ❖ The acceptance of the existence of Dark energy and the Heisenberg's Uncertainty Principle should send the concept of Black Holes as physical reality to the dustbin. The implication of this is that Black Holes as the energy less solutions of Einstein's theory of General relativity is at variant with the widely accepted concept of the nonexistence of energy less state or space (Heisenberg's Uncertainty Principle).
- ❖ Furthermore, if degenerate pressures lead to the existence of White Dwarfs and Neutron stars and then it is highly possible that some processes result in negative pressure or some mysterious quantum processes would set in to avoid the formation of singularity. Since, this is an undisputable possibility, Penrose's cosmic censorship conjecture is always invoke to safe the concept of the existence of Black Hole. Unfortunately, for lovers of Black holes, Numerical calculations have shown the possibility of naked singularity. Also, was Loop quantum gravity to be correct, naked singularities would be possible.

- ❖ Singularity is not only nonsensical and contradicts everything we know about reality; it is abhorrence to nature. Nothing can be more nonsensical than singularity. Infinite mass or energy existing in an infinitesimal space is reality only in imaginations that have run wild. Acceptance of ring singularity as a physical reality and then rejecting naked black holes, white holes and the parallel universe of Kerr's metric as physical realities is tantamount to cherry picking evidences.

More arguments could be provided for why the idea of Black Hole as physical reality should be subjected to rigorous scrutiny but the aforementioned should suffice.

The thrust of my arguments is an uncanny understanding of Active Galactic might come from swallowing hook, line and sinker the classical physics concept of Black hole. It is truly strange that why the rest of the physicists have made superb transition from Classical Physics to Quantum Mechanics, astronomers and astrophysicists continue to hold on to classical concepts like Black Holes.

We submit that a quantum theory of general relativity is need for real breakthrough in the understanding of Active Galactic.

In conclusion, though, brilliant analyses like those undertaken by Shu et al., 2007 give glimpses of the inner working and physical processes occurring and while the unification models of AGN explain can explain some attributes and characteristics of AGN, to make true breakthroughs in our understanding of the mysterious processes and exciting physics occurring deep at the heart of Active Galactic Nuclei comprehensive understanding requires a paradigm shift in our approach. The need to understand magnetic phenomena, galaxy formation, structure and evolution and the need for a theory on Quantum gravity is no longer a luxury, it is must if we intend ever unraveling Active Galactic Nuclei and some of the deepest secret of our universe.

Bibliography

Alexander D. M. 2001, MNRAS, 320, L15

Antonucci, R. R. J. & Miller, J. S. 1985, ApJ, 297, 621

Antonucci, R., and Barvainis, R. 1990, ApJ, 363, L17

Arnaud, K. A., et al, 1987, MNRAS, 227, 241

Aretxaga, I., Joguet, B., Kunth, D., Melnick, J., & Terlevich, R. J. 1999, ApJ, 519, L12

Awaki, H. Murakami, H., Leighly, K., M. Matsumoto, C., Hayashida, K., Grupe, D., 2005, APJ, 632, 793

Awaki H., Koyama K., Inoue H. & Halpern J.P., 1991, PASJ, 43, 195.

Bailey, J., Sparks, W., Hough, J., and Axon, D. 1986, Nature, 322, 150

Barvainis, R. 1987, ApJ, 320, 537

Ballantyne D. R, Fabian, A.C 2005 APJ 622 L97

Barcons X., Carrera, F. J., Ceballos M. T, 2003, MNRAS, 339, 757

Barger, A. J., Cowie, L. L., Mushotzky, R. F., et al. 2005, ApJ, 129, 578

Barthel, P. D. 1989, ApJ, 336, 606

Bassani, L et al., APJS, 121, 473

Bassani L., Dadina M., Maiolino R. et al. 1999, ApJS 121, 473

Bassani L. 1999, ApJS, 121, 473

Baum, S. A., and Heckman, T. M. 1989, ApJ, 336, 681

Blandford, R. D., & Payne, D. G, 1982, MNRAS, 883

Beckmann, V., Gehrels, N., Shrader, C. R., & Soldi, S. 2006, ApJ, 638, 642

Blandford, R. D., Netzer, H., & Woltjer, L., 1990, Active Galactic Nuclei, Spring Verlag, Berlin

Bohlin, R. C., Savage, B. D. & Drake, J. F. 1978, ApJ, 224, 132

Bongiorno, A., et al. 2010, A&A, 510, A56

Bottorff, M., Korista, K. T., Shlosman, I., & Blandford, R.D. 1997, ApJ, 479, 200

Bower et al., 1996, ASPC, 103, 163

Brightman M, Nandra K, 2008, MNRAS, 390, 1241

Brusa, M., et al., 2003, A&A, 409, 65

Caccianiga, A., et al., 2004, A&A, 416, 901

Buchanan, C. L., Gallimore, J. F., O'Dea, C. P., et al. 2006, AJ, 132, 401

Camenzind, M. 2007, Compact objects in Astrophysics, Springer-Verlag, Berlin

Cappi M, et al 2006, A&A, 446, 459

Caccianiga A. et al 2004, A&A 416, 901

Corral, A., Barcons, X., Carrera, F.J., Ceballos, M.T., & Mateos, S. 2005, A&A, 431, 97

Cocchia, F., et al., 2007, A&A, 466, 31

Code et al., 1993, ApJ 403, 63

Comastri, A., Fiore, F., Vignali, C., Matt, G., Perola, G. C., & La Franca, F. 2001, MNRAS, 327, 781

Corral, A., Barcons, X., Carrera, F. J., Ceballos, M. T., & Mateos, S. 2005, A&A, 431, 97

Diamond-Stanic, A. M., Rieke, G. H., & Rigby, J. R. 2009, APJ, 698, 623

Djorgovski, S., Weir, N., Matthews, K., and Graham, J. R. 1991, ApJ, 372, L67

Elvis, M., et al. 1994, ApJS, 95, 1

Elitzur, M. 2007, in ASPC, Vol. 373, The Central Engine of Active Galactic Nuclei, ed. L. C. Ho & J. -W.Wang, 415

Elitzur, M. & Ho, L.C. 2009, ApJ, 701, L91

Elitzur, M., & Shlosman, I. 2006, ApJ, 648, L101

Eracleous, M. Halpern J. P 1994 ApJS 90, 30

Evans, I. N., Ford, H. C., Kinney, A. L., Antonucci, R. R. J., Armus, L., and Caganoff, S. 1991, ApJ, 369, L27

Emmering, R. T., Blandford, R.D., & Shlosman, I. 1992, APJ, 385, 460

Fabbiano, G., Willner, S. P., Carleton, N. P., and Elvis, M. 1986, ApJ, 304, L37

Fan X., et al 2006, AJ, 131 1203

Fan, X., Carilli, C. L., Keating, B. 2006, AR&A, 44, 415F

Fixed, J. D. (2001) Astronomy: Journey to the Cosmic Frontier. New York: McGraw Hill,

Fiore, F., et al., 2003, A&A, 409, 79

Fraquelli, H. A., Storchi-Bergmann, T., & Levenson, N. A. 2003, MNRAS, 341, 449

Fruscione, A et al 2005, APJ, 624, 103

Gallagher, S. C. et al. 2006, ApJ, 644, 709

Gaskell, et al., 2004, ASPC, 311, 61

Genzel R., Pichon C., Eckart A., et al. 2000, MNRAS, 317, 348

Georgantopoulos, I., Zezas, A. & Ward, M.J. 2003ApJ, 584, 129

Gondek, D., Zdziarski, A. A., Johnson, W. N., George, I. M., McNaron-Brown, K., Magdziarz, P., Smith, D., Gruber, D. E., 1996, MNRAS, 282, 646

GU, Q., & Huang, J. 2002, ApJ, 579, 205

Guainazzi, M., Fabian, A. C., Iwasawa, K., Matt, G., Fiore, F. 2005a, MNRAS, 356, 295

Hall, P. B., Gallagher, S. C., Richards, G. T., Alexander, D. M., Anderson, S. F., Bauer, F., Brandt, W. N., & Schneider, D. P. 2006, AJ, 132, 1977

Gu Q., Maiolino R., Dultzin-Hacyan D., 2001, A&A, 366, 765

Haas et al., 2008 ApJ 688, 122

Hao, L. et al., 2005, AJ, 129, 1795

Hasinger, G., Miyaji, T., & Schmidt, M. 2005, A&A, 441, 417

Hasinger, G. 2008, A&A, 490, 905

Hatziminaoglou, E, Fritz, J. & Jarrett, 2009, MNRAS, 399, 1206

Heckmann, T., Krolik, J., Meurer, G. Calzetti, D., Kinney, A., Koratkar, A., Leitherer, C., Robert, C., Wilson, A., 1995, ApJ, 452, 549

Heckman, T. M., Ptak, A., Hornschemeier, A., & Kauffman, G. 2005, APJ, 634, 161

Heisler, C. A., Lumsden, S. L., & Bailey, J. A. 1997, Nature, 385, 700

Hines, D. C. & Wills, B. J. 1993, ApJ, 415, 82

Honig, S.F., Beckert, T., Ohnaka, K., & Weigelt, G. 2006, A&A, 452, 459

Hopkins et al., 2004, AJ, 128, 1112

Hopkins, P. F., Cox, T. J., Hernquist, L., Krause, E. & Robertson. B., 2007, APJ, 669,67

Hough, J. H., Brindle, C. B., Axon, D. J., Bailey, J., and Sparks, W. B. 1987, MNRAS, 224, 1013

Inglis, M. D., et al. 1993, MNRAS, 263, 895

Jackson, N. & Rawlings, S. 1997, MNRAS, 286, 241

Jiang L., et al 2008 AJ 135, 1057

Kartje, J. F., Konigl, A., & Elitzur, M. 1999, ApJ, 513, 180

Kaspi, S., Smith, P. S., Netzer, H., et al. 2000, ApJ, 533, 631

Kay, L. E., & Moran, E. C., 1998, PASP, 110, 1003

Kent, S. M., Dame, T. M. & Fazio, G. 1991, ApJ, 378, 131

Kinney, A.L, Antonucci, R. R. J, Ward, M. J, Wilson, A. S, Whittle, M. 1991, ApJ 377, 100

Konigl, A. &Kartje, J. F. 1994, ApJ, 434, 446

Krolik, J. H. (1999) Active Galactic Nuclei, New Jersey: Princeton Univ. Press,

La Massa et al., 2009, ApJ, 705, 568

Lawrence, A. 1991, MNRAS, 252, 586

Lawrence, A. and Elvis, M. 1982, ApJ, 256, 410

Lebofsky, M. J., and G. H. Rieke, 1980, Nature, 284, 410.

Lee, J. C. et al., 2002, ApJ, 570

Lumsden, S. L. & Alexander, D. M. 2001, MNRAS, 328, L32

Lumsden, S. L., Alexander, D. M., & Hough, J. H. 2004, MNRAS, 348, 1451

Lumsdem, S. L., Heisler, C. A., & Bailey, J. A., Hough, J. H., Young, S. 2001, MNRAS, 327,459

Malizia, A., Bassani, L., Stephen, J. B., et al. 2003, ApJL, 589, L17

Malkan, M. A. 1983, ApJ, 268, 582

Martocchia A., Matt G., 2003, ApJ, 589, L13

Martocchia, A., & Matt, G. 2002, preprint (astro-ph/0210332)

Maiolino, R., Shemmer, O., Imanishi, M., et al. 2007, A&A, 468, 979

Maiolino, R., Mignolis, M. Salviati, M. et al 2001, A&A, 365, 28

Matt et al 2003 MNRAS 342

McCarthy et al., 1990, ApJ, 365, 487

Malizia, A., Bassani, L., Stephen, J.B., Di Cocco, G., Fiore, F., Dean, A.J., 2003, APJ, 589, L17

Malkan, M. A., Gorjian, V., & Tam, R. 1998, ApJS, 117, 25

Mazur, P.O. & Mottola, E. 2004, Proc. Nat. Acad. Sci. 111, 9545

MelÅLendez, M., et al. 2008, ApJ, 682, 94

Miller, J. S., & Goodrich, R. W., 1990, ApJ, 355, 456

Moran, E. C., Filippenko, A. V., & Chornock, R. 2002, ApJ, 579, L71

Moran, E. C., Barth, A. J., Kay, L. E., & Filippenko, A. V. 2000, ApJ, 540, L73

Moran, E.C., et al., 2005, AJ, 129, 2108

Mulchaey, J. S., et al., 1994, ApJ, 436, 586

Mulchaey J.S., Wilson A.S., Tsvetanov Z., 1996, ApJS, 102, 309

Mulchaey, J. S., et al., 1997, ApJ, 477

Nandra, K., George, I. M., Mushotzky, R. F., Turner, T. J., & Yaqoob, T. 1997, ApJ, 477, 602

NenKova, M., Ivezic, Z., Elitzur, M. 2000 ASPC 196 77N

Nenkova, M., Sirocky, M.M, Nikutta, R., Ivezic, I. & Elitzur, M. 2008, ApJ
Szokoly, G. P., et al., 2004, ApJS, 155, 271

Netzer, H., Mainieri, V., Rosati, P., & Trakhtenbrot, B. 2006, A&A, 453, 525Nicastro F.,

Ogle, P., Whysong, D., Antonucci, R., 2006, ApJ, 647, 161

Panessa F., Bassani L., 2002, A&A, 394, 435

Pappa A., Georgantopoulus I., Stewart G. C., Zezas A., 2001, MNRAS, 326, 995

Paolillo, M., Schreier, E. J., Giacconi, R., Koekemoer, A. M., & Grogin, N. A. 2004, ApJ, 611, 93

Perola, G. C., Matt, G., Cappi, M., Fiore, F., Guainazzi, M., Maraschi, L., Petrucci, P. O., Piro, L., 2002, A&A, 389, 802

Petterson, B.M. (1997) An Introduction to Active Galactic Nuclei. Cambridge: Cambridge Univ. Press.

Pogge, R. 1988, APJ, 328, 519

Rees, M. J., J. Silk, M. W. Warner, and N. C. Wickramasinghe, 1969, Nature, 223, 788.

Risaliti, G., Maiolino, R., & Bassani, L. 200, A&A, 356, 3

Risaliti, G. & Elvis, M. 2004, ASSL Vol. 308: Supermassive Black Holes in the Distant Universe, 187

Risaliti, G., Maiolino, R. & Salviati, M 1999, ApJ 522, 157

Risaliti et al 2007 APJ 659 L111

Robinson, A., Binette, L., Fosbury, R. A. E., and Tadhunter, C. N. 1987, MNRAS, 227, 97

Rowan Robinson, M 1977, ApJ, 213, 638

Roy, A. L, Norris, R. P, Kesteven, M. J, Troup, E. R, Reynold, J. E. 1994, ApJ 432, 496R

Sanders, D. B., Phinney, E. S, Neugebauer, G., Soifer, B. T. and Matthews, K. 1989, ApJ, 347, 29

Sch.del, R., Ott, T., Genzel, R., et al. 2003, ApJ, 596, 1015

Schiller, C, (2005) The Adventure of Physics. New York: John Wiley

Schmitt, H. R., Antonucci, R. Ulvestad, J. S, Kinney, A. L, Clarke, C. J & Pringle, J. E., 2001, APJ 555, 663

Schultz, G. V. & Wiener, W. 1975 A&A 43 133s

Severgnini, P., et al., 2003, A&A, 406, 483

Silverman, J. D., Green, P. J., Barkhouse, W. A., et al. 2005, ApJ, 618, 123

Smith, D. A., & Done, C., 1996, MNRAS, 280, 355

Smith D.A., Done C. 1996, MNRAS 280, 355

Smith, D. A., & Wilson, A. S., 2001, ApJ, 557, 180

Storchi-Bergmann, T. Raimann, D. Bica, E. L.D. Fraquelli, H. A., 2000, ApJ, 544, 747

Shu, X. W., Wang, J. X., Jiang, P., Fan, L. L., & Wang, T. G. 2007, ApJ, 657, 167

Shu, X., Wang, J., & Jiang, P. 2008, Chinese Journal of Astronomy and Astrophysics, 8, 204

Shu, X.W., Liu, T., and Wang, J.X. 2010, ApJ 722, 96

Sun, W. H & Malkan, M. A. 1989, IA US, 134, 262

Sunyaev, R. A. and Titarchuk, L. G. (1980). Comptonization of X-rays in plasma clouds-typical radiation spectra. A&A, 86, 121.138

Tadhunter, C. N., and Tsvetanov, Z. 1989, Nature, 341, 422

Tajer, M., et al., 2007, A&A, 467, 73

Tozzi, P., R. et al., 2006, A&A, 451, 457

Tran, H. D., 1995, ApJ, 440, 565

Tran, H. D., 2001, ApJ, 554, L19

Tran, H. D., 2003, ApJ, 583, 632

Tran, H. D., Miller, J. S., & Kay, L. E., 1992, ApJ, 397, 452

Turner T.J., Pounds K.A. 1988, MNRAS 232, 463

Treister, E. & Urry, C.M., 2006, APJ 652, L79

Treister, E. & Urry, C. M. 2005, ApJ, 630, 115

Treister, E., Natarajan, P., Sanders, D., et al. 2010, Science, 328, 600

Tsiklauri, D., Viollier, R. D. 1998, ApJ 501, 486T

Turner, T. J., George, I. M., Nandra, K., & Mushotzky, R. F. 1997, ApJS, 113, 23

Ueda, Y., Akiyama, M., Ohta, K., & Miyaji, T., 2003, APJ 598, 886

Ueno, S., Koyama, K., Nishida, M., Yamauchi, S. & Ward, M.J. 1994, ApJ, 431, L1

Urry, C.M., & Padovani, P. 1995, PASP, 107,803

Vignali, C. et al., 1997, http://arxiv.org/pdf/astro-ph/9712250

Wang, J.X., Jiang, P., Zheng, Z.Y., et al., 2007, APJ 657, 95

Wang, J. M & Zhang, E.P 2007, APJ 660, 1072

Ward, M. J. et al., 1994, ApJ, 431 L1

Wild, V., Heckman, T & Charlot, S. 2010, MNRAS, 405, 933

Wilm, Jorn. 2010 (http://pulsar.sternwarte.uni-erlangen.de/wilms)

Wilkes, B. J. et al. 2002, ApJ, 564, L65

Wilson A.S., Elvis M., Lawrence A., Bland-Hawthorn J., 1992, ApJ 391, L75

Wilson, A. S., Braatz, J., Heckman, T. M., Krolik, J. H., and Miley, G. K. 1993, ApJ, 419, L61

Wolter A. et al 2005, A&A, 444, 165

Wu, Z., Gu, M., & Zhu, M. 2011 arXiv 1104.4876

Young, S., et al., 1996, MNRAS, 281, 1206

Yuan, F. 2007, in ASP Conf. Ser. 373: The Central Engine of Active Galactic Nuclei,

Zdziarski, A. A., Johnson, W. N., Done, C., Smith, D., & McNaron-Brown, K. 1995, ApJL, 438, L63

(1) http://openlearn.open.ac.uk/mod/oucontent/view.php?id=398724&section=2.2

(2) http://openlearn.open.ac.uk/mod/oucontent/view.php?id=398724&section=5.1

(3)

(4) http://en.wikipedia.org/wiki/No_hair_theorem

(5) http://openlearn.open.ac.uk/mod/oucontent/view.php?id=398724&section=4.7

(6)

(7) http://pulsar.sternwarte.uni-erlangen.de/wilms

(8) (3) http://pulsar.sternwarte.uni-erlangen.de/wilms

(9) (4) Www.wikipedia.org/torus/image

This work is dedicated to my father and mother, Mr. & Mrs. Yonton B. Kesselly for all their helps and supports.

致 谢

I would like to take the opportunity to thank the following people for their helps and supports. Thanks go to my supervisor, Prof. Jun xian Wang for discussions, for providing guidance and for critically reading the manuscript of this work and providing corrections, which have greatly improved this work. I appreciate all the professors, lecturers and staffs at the Department of Astronomy and the Center for Astrophysics of the University of Science and Technology of China, for their contributions to this work and to my insights into the field of Astrophysics. They are also acknowledged for their friendliness and for providing an excellent working and studying environment. I'm truly grateful to my colleagues at the Department of Astronomy and the Center for Astrophysics, particularly Dr. Xinwen Shu, for their supports, encouragements and understanding, without which this work would never had been possible. Thanks are also due my brothers and friends Mr. Edman Zayzay, Varney Soko Clarke who timely interventions lead to the success of this work. My overwhelming gratefulness goes to the Biam family particularly Azzahemen and Torva Biam and all my friends for their unwavering helps and supports. Finally, I will like to thank my parents and siblings for all their support and understanding.

在读期间发表的学术论文与取得的研究成果

[1] Kesselly Alton Vanie . Intrinsic Variation as the Outcome of the Asymmetries in Magnetic Field Topology. In preparation