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Accepted Abstracts - Submitted Abstracts - Thesis Abstracts
Jobs Adverts - Meetings Adverts - Special Announcements

From the Editor

The Active Galaxies Newsletter is produced monthly. The deadline for contributions is the last friday of the month. The Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter and are also available on the web page.

As always as editor of the newsletter I am very interested to hear any suggestions or feedback regarding the newsletter. So do not hesitate in emailing me your suggestions.

Many thanks for your continued subscription.

Rob Beswick

Abstracts of recently accepted papers

Silicates in Ultra-Luminous Infrared Galaxies

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We analyze the mid-infrared (MIR) spectra of ultraluminous infrared galaxies (ULIRGs) observed with the *Spitzer Space Telescope*'s Infrared Spectrograph. Dust emission dominates the MIR spectra of ULIRGs, and the reprocessed radiation that emerges is independent of the underlying heating spectrum. Instead, the resulting emission depends sensitively on the geometric distribution of the dust, which we diagnose with comparisons of numerical simulations of radiative transfer. Quantifying the silicate emission and absorption features that appear near 10 and 18μm requires a reliable determination of the continuum, and we demonstrate that including a measurement of the continuum at intermediate wavelength (between the features) produces accurate results at all optical depths. With high-quality spectra, we successfully use the silicate features to constrain the dust chemistry. The observations of the ULIRGs and local sightlines require dust that has a relatively high 18/10μm absorption ratio of the silicate features (around 0.5). Specifically, the cold dust of Ossenkopf et al. (1992) is consistent with the observations, while other dust models are not. We use the silicate feature strengths to identify two families of ULIRGs, in which the dust distributions are fundamentally different. Optical spectral classifications are related to these families. In ULIRGs that harbor an active galactic nucleus, the spectrally broad lines are detected only when the nuclear surroundings are clumpy. In contrast, the sources of lower ionization optical spectra are deeply embedded in smooth distributions of optically thick dust.

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preprint available at http://arxiv.org/abs/0801.4776

Fast outflows in compact radio sources: evidence for AGN-induced feedback in the early stages of radio source evolution

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We present intermediate resolution, wide wavelength coverage spectra for a complete sample of 14 compact radio sources taken with the aim of investigating the impact of the nuclear activity on the circumnuclear interstellar medium (ISM) in the early stages of radio source evolution. We observe spatially extended line emission (up to ∼20 kpc) in the majority of sources which is consistent with a quiescent halo. In the nuclear apertures we observe broad, highly complex emission line profiles. Multiple Gaussian modelling of the [O III]λ5007 line reveals between 2 and 4 components which can have velocity widths (FWHM) and blueshifts relative to the halo of up to ∼2000km s^{-1}. We interpret these broad, blueshifted components as material in outflow and discuss the kinematical evidence for jet-driven outflows as previously proposed for PKS 1549-79 and PKS 1345+12. Comparisons with samples in the literature show that compact radio sources harbour more extreme nuclear kinematics than their extended counterparts, a trend seen within our sample with larger velocities in the smaller sources. The observed velocities are also likely to be influenced by source orientation with respect to the observer's line of sight. Nine sources have associated HI absorption. In common with the optical emission line gas, the HI profiles are often highly complex with the majority of the detected components significantly blueshifted, tracing outflows in the neutral gas. The sample has been tested for stratification in the ISM (FWHM/ionisation potential/critical density) as suggested by Holt et al (2003) for PKS 1345+12 but we find no significant trends within the sample using a Spearman Rank analysis. This study supports the idea that compact radio sources are young radio loud AGN observed during the early stages of their evolution and currently shedding their natal cocoons through extreme circumnuclear outflows.

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Properties of dusty tori in AGN: I. The Case of SWIRE/SDSS Quasars

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We derive the properties of dusty tori in Active Galactic Nuclei (AGN) from the comparison of observed Spectral Energy Distributions (SEDs) of SDSS quasars and a precomputed grid of torus models. The observed SEDs comprise SDSS photometry, 2MASS J, H, and K data, whenever available and mid-Infrared (MIR) data from the Spitzer Wide-area InfraRed Extragalactic (SWIRE) Survey. The adopted model is that of Fritz et al. (2006). The fit is performed by standard χ^2 minimisation, the model however can be multi-component comprising a stellar and a starburst components, whenever necessary. Models with low equatorial optical depth, $\tau_{9.7}$, were allowed as well as "traditional" models with $\tau_{9.7} \geq 1.0$, corresponding to $A_V \geq 22$ and the results were compared. Fits using high optical depth tori models only produced dust more compactly distributed than in the configuration where all $\tau_{9.7}$ models were permitted. Tori with decreasing dust density with the distance from the centre were favoured while there was no clear preference for models with or without angular variation of the dust density. The computed outer radii of the tori are of some tens of parsecs large but can reach, in a few cases, a few hundreds of parsecs. The mass of dust, M_{Dust}, and infrared luminosity, L_{IR}, integrated in the wavelength range between 1 and 1000 μm, do not show significant variations with redshift, once the observational biases are taken into account. Objects with 70 μm detections, representing 25%

of the sample, are studied separately and the starburst contribution (whenever present) to the IR luminosity can reach, in the most extreme but very few cases, 80%.

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Chandra unveils a binary Active Galactic Nucleus in Mrk 463

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We analyse *Chandra*, XMM-*Newton* and *HST* data of the double-nucleus Ultraluminous Infrared Galaxy (ULIRG), Mrk 463. The *Chandra* detection of two luminous ($L_{2-10\,\mathrm{keV}} = 1.5 \times 10^{43}$ and 3.8×10^{42} erg cm^{-2} s^{-1}), unresolved nuclei in Mrk 463 indicates that this galaxy hosts a binary AGN, with a projected separation of $\simeq 3.8$ kpc (3.83 ± 0.01 arcsec). While the East nucleus was already known to be a Seyfert 2 (and this is further confirmed by our *Chandra* detection of a neutral iron line), this is the first unambiguous evidence in favour of the AGN nature of the West nucleus. Mrk 463 is therefore the clearest case so far for a binary AGN, after NGC 6240.

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A Significant Population of Very Luminous Dust-Obscured Galaxies at Redshift $z \sim 2$

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Observations with the *Spitzer Space Telescope* have recently revealed a significant population of high-redshift ($z \sim 2$) dust-obscured galaxies with large (rest-frame) mid-infrared to ultraviolet luminosity ratios. Due to their optical faintness, these galaxies have been previously missed in traditional optical studies of the distant universe. ?We present a simple method for selecting this high-redshift population based solely on the ratio of the observed mid-infrared 24μm to optical R-band flux density. We apply this method to observations of the ≈ 8.6 deg^2 Boötes Field of the NOAO Deep Wide-Field Survey, and uncover $\approx$2,600 dust-obscured galaxy candidates (i.e., a surface density of 0.089 arcmin^{-2}) with 24μm flux densities $F_{24\mu\mathrm{m}} \geq 0.3$mJy and $(R-[24]) \geq 14$ (i.e., $F_\nu(24\mu\mathrm{m})/F_\nu(R) \gtrsim 1000$). These galaxies have no counterparts in the local universe. They become a larger fraction of the population at fainter 24μm flux densities, increasing from 7$\pm$0.6% of sources at $F_{24\mu\mathrm{m}} \geq 1$ mJy to $\approx 13 \pm 1$% of the population at ≈ 0.3 mJy. ?These galaxies exhibit evidence of both star-formation and AGN activity, with the brighter 24μm sources being more AGN-dominated. Their mid-infrared spectral energy distributions range from power-laws (likely AGN-dominated at mid-IR wavelengths) to systems showing a "bump", the latter likely resulting from the redshifted 1.6μm peak characteristic of most stellar populations. Using primarily the W. M. Keck Observatory and *Spitzer*, we have obtained spectroscopic redshifts for 86 objects within?this sample, and find a broad redshift distribution which can be modeled as a Gaussian centered at $\bar{z} \approx 1.99 \pm 0.05$ and $\sigma(z) \approx 0.45 \pm 0.05$. The space density of this population is $\Sigma_{\mathrm{DOG}}(F_{24\mu\mathrm{m}} \geq 0.3\ \mathrm{mJy}) = (2.82 \pm 0.05) \times 10^{-5} h_{70}^3$ Mpc^{-3}, similar to that of bright sub-millimeter-selected or UV-selected galaxies at comparable redshifts.

These redshifts also imply very large luminosities, with a sample median $\nu L_\nu(8\mu\mathrm{m}) \approx 4 \times 10^{11}\mathrm{L}_\odot$, implying $8\mu\mathrm{m} - 1\mathrm{mm}$ luminosities of $L_{\mathrm{IR}} \gtrsim 10^{12-14}\mathrm{L}_\odot$ for the population. The infrared luminosity density contributed by this relatively rare dust-obscured galaxy population is log(IRLD) $\approx 8.23^{+0.18}_{-0.30}$. This is $\approx 60^{+40}_{-15}\%$ of that contributed by $z \sim 2$ ultraluminous infrared galaxies (ULIRGs, with $L_{\mathrm{IR}} > 10^{12}\mathrm{L}_\odot$), and suggests that our simple selection criterion effectively identifies a significant fraction of $z \sim 2$ ULIRGs. This IRLD is also $\approx 26 \pm 14\%$ of the total contributed by all $z \sim 2$ galaxies, and comparable to that contributed by the luminous UV-bright star-forming galaxy populations at $z \approx 2$. We suggest that these dust-obscured galaxies are the progenitors of luminous ($\sim 4L^*$) present-day galaxies and are undergoing an extremely luminous, short-lived phase of both bulge and black hole growth. They may represent a brief evolutionary phase between sub-millimeter-selected galaxies and less obscured quasars or galaxies.

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Spitzer Mid-Infrared Spectroscopy of Distant X-ray Luminous AGN

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We present mid-infrared spectroscopy of a sample of 16 optically faint infrared luminous galaxies obtained with the Infrared Spectrograph (IRS) on the *Spitzer Space Telescope*. These sources were jointly selected from *Spitzer* and *Chandra* imaging surveys in the NDWFS Boötes field and were selected from their bright X-ray fluxes to host luminous AGN. None of the spectra show significant emission from polycyclic aromatic hydrocarbons (PAHs; 6.2μm equivalent widths <0.2μm), consistent with their infrared emission being dominated by AGN. Nine of the X-ray sources show 9.7μm silicate absorption features. Their redshifts are in the range $0.9 < z < 2.6$, implying infrared luminosities of log(L_{IR}) =12.5−13.6 $L_\odot$. The average silicate absorption strength is not as strong as that of previously targeted optically faint infrared luminous galaxies with similar mid-infrared luminosities implying that the X-ray selection favors sources behind a smaller column of Si- rich dust than non-X-ray selection. Seven of the X-ray sources have featureless power-law mid-IR spectra. We argue that the featureless spectra likely result from the sources having weak or absent silicate and PAH features rather than the sources lying at higher redshifts where these features are shifted out of the IRS spectral window. We investigate whether there are any correlations between X-ray and infrared properties and find that sources with silicate absorption features tend to have fainter X-ray fluxes and harder X-ray spectra, indicating a weak relation between the amount of silicate absorption and column density of X-ray-absorbing gas.

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The effect of radiation pressure on virial black hole mass estimates and the case of Narrow Line Seyfert 1 galaxies

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We consider the effect of radiation pressure from ionizing photons on black hole (BH) mass estimates based on the application of the virial theorem to broad emission lines in AGN spectra. BH masses based only on the virial product $\Delta V^2 R$ and neglecting the effect of radiation pressure can be severely underestimated especially in objects close to the Eddington limit. We provide an empirical calibration of the correction for radiation pressure and we show that it is consistent with a simple physical model in

which BLR clouds are optically thick to ionizing radiation and have average column densities of $N_{\rm H} \sim 10^{23}\,{\rm cm}^{-2}$. This value is remarkably similar to what is required in standard BLR photoionization models to explain observed spectra. With the inclusion of radiation pressure the discrepancy between virial BH masses based on single epoch spectra and on reverberation mapping data drops from 0.4 to 0.2 dex rms. The use of single epoch observations as surrogates of reverberation mapping campaigns can thus provide more accurate BH masses than previously thought. Finally, we show that Narrow Line Seyfert 1 (NLS1) galaxies have apparently low BH masses because they are radiating close to their Eddington limit. After the radiation pressure correction, NLS1 galaxies have BH masses similar to other broad line AGNs and follow the same $M_{\rm BH} - \sigma/L$ relations as other active and normal galaxies. Radiation forces arising from ionizing photon momentum deposition constitute an important physical effect which must be taken into account when computing virial BH masses.

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Heavy absorption and soft X-ray emission lines in the XMM–Newton spectrum of the Type 2 radio-loud quasar 3C 234

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We report results on a 40 ks XMM-Newton observation of the Type 2 quasar 3C 234. Optical spectropolarimetric data have demonstrated the presence of a hidden broad-line region in this powerful ($M_V \leq -24.2$ after reddening and starlight correction) narrow-line FRII radio galaxy. Our analysis is aimed at investigating the X-ray spectral properties of this peculiar source that have remained poorly known so far. We analyze the 0.5–10 keV spectroscopic data collected by the EPIC cameras in 2006. The X-ray spectrum of this radio-loud quasar is typical of a local Compton-thin Seyfert 2 galaxy. It exhibits strong absorption ($N_{\rm H} \sim 3.5 \times 10^{23}$ cm^{-2}) and a narrow, neutral Fe Kα emission line with an equivalent width of ≈140±40 eV. Our observation also reveals that the soft portion of the spectrum is characterized by strong emission lines with a very low level of scattered primary continuum. A possible explanation of these features in terms of thermal emission from a two-temperature, collisionally ionized plasma emission seems to be unlikely due to the high luminosity estimated for this component ($L_{0.5-2} \sim 6 \times 10^{42}$ erg s^{-1}). It is likely that most of the soft X-ray emission originates from a photoionized plasma as commonly observed in obscured, radio-quiet Seyfert-like AGNs. This X-ray observation has definitively confirmed the presence of a hidden quasar in 3C 234. The line-rich spectrum and the steepness of the hard X-ray continuum ($\Gamma \approx 1.7$) found in this source weaken the hypothesis that the bulk of the X-ray emission in radio-loud AGNs with high-excitation optical lines arises from jet non-thermal emission.

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Probing the Ionization Structure of the Narrow Line Region in the Seyfert 1 Galaxy NGC 4151

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We present a study of the distribution of [O III] λ5007 and [O II] λ3727 emission in the Narrow Line Region (NLR) of the Seyfert 1 galaxy NGC 4151. While the NLR of NGC 4151 exhibits an overall structure consistent with the unified model of Seyfert galaxies, narrow-band [O III] and [O II] images obtained with the Wide Field and Planetary Camera 2 aboard the *Hubble Space Telescope* reveal significant emission from outside the the emission-line bi-cone. The [O III]/[O II] ratios are lower in these regions, consistent with a weaker ionizing flux. We performed a photoionization modeling analysis of the emission-line gas within a series of annuli, centered on the the central continuum source, with inner radii from 13 to 90 pc. The gas is ionized by radiation that has been attenuated by a relatively highly-ionized absorber (HABS), which completely covers the central source, and a lower-ionization absorber (LABS), which has a covering factor ranging from 0 to 1. We found that the [O III]/[O II]

ratios are well fit by assuming that, within each segment of an annulus, some fraction of the NLR gas is completely within the shadow of LABS, while the rest is irradiated by the continuum filtered only by HABS. This suggests that the structure of the NLR is due to filtering of the ionizing radiation by ionized gas, consistent with disk-wind models. One possible scenario is that the low-ionization absorbers are dense knots of gas swept up by a wind.

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Opacity in compact extragalactic radio sources and its effect on astrophysical and astrometric studies

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The apparent position of the "core" in a parsec-scale radio jet (a compact, bright emitting region at the narrow end of the jet) depends on the observing frequency, owing to synchrotron self-absorption and external absorption. While providing a tool probing physical conditions in the vicinity of the core, this dependency poses problems for astrometric studies using compact radio sources.

We investigated the frequency-dependent shift in the positions of the cores (*core shift*) observed with very long baseline interferometry (VLBI) in parsec-scale jets. We discuss related physics, as well as its effect on radio astrometry and the connection between radio and optical positions of astrometric reference objects.

We searched for the core shift in a sample of 277 radio sources imaged at 2.3 GHz (13 cm) and 8.6 GHz (4 cm) frequency bands using VLBI observations made in 2002 and 2003. The core shift was measured by referencing the core position to optically thin jet features whose positions are not expected to change with frequency.

We present here results for 29 selected active galactic nuclei (AGN) with bright distinct VLBI jet features that can be used in differential measurements and that allow robust measurements of the shift to be made. In these AGN, the magnitude of the measured core shift between 2.3 and 8.6 GHz reaches 1.4 mas, with a median value for the sample of 0.44 mas. Nuclear flares result in temporal variability of the shift.

An average shift between the radio (4 cm) and optical (6000 Å) bands is estimated to be approximately 0.1 mas, and it should be taken into account in order to provide the required accuracy of the radio-optical reference frame connection. This can be accomplished with multi-frequency VLBI measurements yielding estimates of the core shift in the sources used for the radio reference frame and radio-optical position alignment.

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X-ray spectral variability in PG 1535+547: the changing-look of a "soft X-ray weak" AGN

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PG 1535+547 is a bright Narrow Line Seyfert 1 galaxy, whose high energy emission shows strong variability both in shape and flux. On the basis of *ROSAT* observations, it is classified as "soft X-ray weak QSO", a class of objects whose X-ray–to–optical flux ratio is smaller than in typical QSOs. Their X-ray spectra are often characterized by highly ionized, complex absorbers and/or reflection from the inner accretion disk, and the relative importance of the two is currently debated. Whatever the correct interpretation may be, the presence of such features implies that we are looking at matter located in the innermost regions of these AGN.

We want to clarify the nature of the X-ray emission of PG 1535+547, and constrain the physical properties of its innermost regions, where this emission originates.

We present new XMM-*Newton* observations of PG 1535+547 (90 ksec exposure time), from which we obtained two spectra separated by about one week, that we compare with a previous (about three years) XMM-*Newton* observation.

These observations support the complex and variable nature of the X-ray emission of PG 1535+547. The broad band observed flux increases by a factor ~ 2.3 in three years, and then decreases by a factor ~ 1.3 in about one week. In the new EPIC spectra strong absorption features at $E < 3$ keV and a complex spectral shape in the iron line energy range are evident, coupled with a drop in the emission at higher energies. We describe all the different states in a consistent way, assuming either a warm absorber plus a relativistically blurred ionized reflection, or a two-phase warm absorber partially covering the source with the addition of a scattered component.

The observed variability can be ascribed mostly to warm absorbing gas in the innermost regions of PG 1535+547, that appears to vary in its physical properties on timescales of both years and days. In the blurred reflection scenario all the analysed states require a high fraction of reflection from the disk, calling for some mechanisms able to increase the reflection component with respect to the intrinsic continuum. Finally, the strong variability observed in the X-ray band opposed to a more constant emission at optical frequencies changes the value of the X-ray–to–optical spectral index, implying that PG 1535+547 can not actually be classified as a soft X-ray weak AGN.

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Tracing a Disk Wind in NGC 3516

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X-ray spectra of AGN often contain signatures indicative of absorption in multiple layers of gas whose ionization-state and covering fraction may vary with time. It has been unclear to date how much of the observed X-ray spectral and timing behavior in AGN can be attributed to variations in absorption, versus variations in the strengths of emission or reflection components. Diagnostics of the inner regions of AGN cannot be reliably performed until the origin of observed effects is understood.

We investigate the role of the X-ray absorbers in the Seyfert 1 galaxy NGC 3516. Time-averaged and flux-selected spectroscopy is used to examine the behavior of NGC 3516 observed in Chandra HETG and XMM data from Oct 2006. New H-like and He-like emission and absorption features discovered in the Fe K regime reveal a previously unknown zone of circumnuclear gas in NGC 3516 with $\log \xi \sim 4.3$ and column density $\sim 10^{23}\mathrm{cm}^{-2}$. A lower-ionization layer with $\log \xi \sim 2$ and of similar column density is confirmed from previous observations, this layer has a covering fraction around 50%, and changes in covering provide a simple explanation of a deep dip in the light curve that we interpret as an eclipse of the continuum due to passage of a cloud across the sight line within half a day. These inner zones of absorbing gas are detected to have outflow velocities in the range $1000 - 2000\,\mathrm{km\,s^{-1}}$, this, and constraints on radial location are consistent with an origin as part of a disk wind in NGC 3516.

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Thesis Abstracts

Clumpy Dust Tori in Active Galactic Nuclei

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Active Galactic Nuclei (AGN) are amongst the most luminous objects in the universe. The source of their activity is accretion onto a supermassive black hole in the center of the galactic nucleus. The various phenomena observed in AGN are explained in a common unification scheme. The cornerstone of this unification scheme of AGN is the presence of an optically and geometrically thick dust torus which surrounds the central accretion disk and broad-line region (BLR). This parsec-scaled torus is responsible for the apparent difference between type 1 and type 2 AGN. If the line-of-sight intersects with the torus, the accretion disk and BLR are not visible and the AGN is classified as a type 2 object. On the other hand, if the torus is seen nearly face-on, the accretion disk and BLR are directly exposed to the observer, so that the galaxy appears as a type 1 AGN.

Near- (NIR) and mid-infrared (MIR) interferometry has resolved, for the first time, the dust torus around the nearby prototypical Seyfert 2 AGN NGC 1068. These observations provided an insight into the structure of the torus: Apparently, the dust is not smoothly distributed in the torus but arranged in clumps — contrary to what has been commonly used in models.

We developed a new radiative transfer model of clumpy dust tori which is a key tool to interpret NIR and MIR observations of AGN. The model accounts for the 3-dimensional arrangement of dust clouds. Model SEDs and images can be obtained for a number of different physical parameters (e.g., radial and vertical dust density distribution, cloud radii, optical depths, etc.). It was shown that the model SEDs are in agreement with observed spectral properties. Moreover, we applied our new model to the data of NGC 1068. It was possible, for the first time, to simultaneously reproduce NIR and MIR interferometry and photometry of the nucleus of NGC 1068. In particular, the model follows the trend of the deeper $9.7\,\mu$m silicate absorption features in the correlated fluxes than in the total fluxes, as observed with VLTI/MIDI in the $8-13\,\mu$m band. Comparison with the NGC 1068 multi-wavelength SED from Radio to the infrared shows that most of the unresolved MIR flux comes from thermal dust emission inside the torus, while in the NIR a possible synchrotron source or the accretion disk might be seen through "holes" in the clumpy torus.

To get a better idea how much the accretion disk contributes to the NIR emission of AGN, we studied NIR colors of a sample of type 1 AGN which were observed in J-, H-, and K-band with HST/NICMOS. By comparing the observed colors with those expected from torus models, we found out that the accretion disk contributes typically $< 25\%$ to the K-band flux. The observed colors also indicate that the sublimation temperature is probably close to $\sim$1500 K, but not significantly higher. In addition, reverberation radii of type 1 AGN were compared to theoretical predictions for the dust sublimation radius. Apparently, the reverberation radii are about a factor of 3 smaller than the expected sublimation radius for standard ISM dust grains. This discrepancy can be solved if the inner torus region is dominated by large carbon grains.

We studied the feedback of AGN radiation on the dust torus. It was found out that dust which is smoothly distributed cannot withstand the radiation pressure from the AGN. On the other hand, self-gravitating clouds in clumpy tori can efficiently compensate the AGN radiation pressure. A physically-motivated clumpy torus model was used to study the impact of the AGN radiation on obscuration properties of the torus. We showed that below an AGN luminosity of $\sim 10^{42}\,\mathrm{erg\,s^{-1}}$, the associated low accretion rates can no longer support an obscuring torus. In the high-luminosity regime, large clouds become unbound so that the torus is dominated by smaller clouds. As a result, the covering factor and apparent scale height decrease with luminosity, so that the fraction of type 1 AGN should become larger at higher luminosities (and high radiative efficiencies). This picture offers a physical explanation for the long-standing "receding torus" phenomenon.

One of the major astronomical discoveries within the last year was the identification of type 2 counterparts of QSOs. These objects were the "missing link" in the unification scheme. We studied restframe optical-to-MIR SEDs of a sample of 21 obscured QSOs with our clumpy torus model. It was found out that the observed SEDs favor models with compact geometries and, apparently, no flaring. In some objects, the combination of blue NIR color and very deep silicate absorption is in contradiction

to expectations from torus models. We propose that in such cases, the torus is actually seen face-on, and a detached cold absorber in the host galaxy (e.g., a dust lane or cloud) is responsible for the deep silicate absorption feature. According to this picture, some of the obscured QSOs are mimicking type 2 AGN although their torus orientation might be similar to a type 1 AGN.

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