



Active Galactic Nuclei at All Wavelengths and from All Angles

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AGN are quite unique astronomical sources emitting over more than 20 orders of magnitude in frequency, with different electromagnetic bands providing windows on different sub-structures and their physics. They come in a large number of flavors only partially related to intrinsic differences. I highlight here the types of sources selected in different bands, the relevant selection effects and biases, and the underlying physical processes. I then look at the “big picture” by describing the most important parameters one needs to describe the variety of AGN classes and by discussing AGN at all frequencies in terms of their sky surface density. I conclude with a look at the most pressing open issues and the main new facilities, which will flood us with new data to tackle them.

Keywords: quasars, active galactic nuclei, supermassive black holes, radio emission, infrared emission, X-ray emission, γ -ray emission

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1. INTRODUCTION

AGN are, by definition, more powerful than the nuclei of normal galaxies. This “additional” component is now universally accepted to be due to an actively accreting central supermassive ($\gtrsim 10^6 M_{\odot}$) black hole (SMBH). This implies a number of fascinating properties, which include very high luminosities (up to $L_{\text{bol}} \approx 10^{48} \text{ erg s}^{-1}$), small emitting regions in most bands (of the order of a milliparsec), strong evolution of the luminosity functions, and broad-band emission covering the entire electromagnetic spectrum (see Padovani et al., 2017, for a review).

The latter property means that AGN have been discovered at all wavelengths. This is partly responsible for the very large number of classes and sub-classes AGN researchers have come up with (see **Table 1**), which appear to be overwhelming and very confusing, especially to astronomers working in other fields and particularly to physicists.

Different methods are employed to select AGN in the various bands, which also provide different views on AGN physics. I discuss this next. I refer to Padovani et al. (2017) for a more in-depth review of these (and other) topics.

2. THE RADIO BAND

One of the main results of the past few years has been the realization that the radio sky population undergoes major changes at low flux densities. Namely, while the bright radio sky ($f_{\text{r}} \gtrsim 1 \text{ mJy}$ around 1 GHz, where 1 Jy is $10^{-23} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ Hz}^{-1}$) is populated mostly by radio galaxies (RGs) and radio quasars, that is largely non-thermal sources, at faint radio flux densities we are now detecting mainly star-forming galaxies (SFGs) and the more common non-jetted AGN (see Padovani, 2016, for a review). This change is also apparent by looking at the Euclidean normalized 1.4 GHz source counts, which show an upturn around $\approx 0.1 \text{ mJy}$ (see **Figure 1**). We therefore need to deal separately with the two flux density regimes.

TABLE 1 | The AGN zoo: list of AGN classes.

Class/Acronym	Meaning/Main properties
Quasar	Quasi-stellar radio source (originally)
Sey1	Seyfert 1, $\text{FWHM} \gtrsim 1,000 \text{ km s}^{-1}$
Sey2	Seyfert 2, $\text{FWHM} \lesssim 1,000 \text{ km s}^{-1}$
QSO	Quasi-stellar object
QSO2	Quasi-stellar object 2, high power Sey2
RQ AGN	Radio-quiet AGN
RL AGN	Radio-loud AGN
Jetted AGN	With strong relativistic jets
Non-jetted AGN	Without strong relativistic jets
Type 1	Sey1 and quasars
Type 2	Sey2 and QSO2
FR I	Fanaroff-Riley class I radio source
FR II	Fanaroff-Riley class II radio source
BL Lac	BL Lacertae object
Blazars	BL Lacs and FSRQs
BAL	Broad absorption line (quasar)
BLO	Broad-line object, $\text{FWHM} \gtrsim 1,000 \text{ km s}^{-1}$
BLAGN	Broad-line AGN, $\text{FWHM} \gtrsim 1,000 \text{ km s}^{-1}$
BLRG	Broad-line radio galaxy
CDQ	Core-dominated quasar
CSS	Compact steep spectrum radio source
CT	Compton-thick
FR 0	Fanaroff-Riley class 0 radio source
FSRQ	Flat-spectrum radio quasar
GPS	Gigahertz-peaked radio source
HBL/HSP	High-energy cutoff BL Lac/blazar
HEG	High-excitation galaxy
HPQ	High polarization quasar
Jet-mode	
IBL/ISP	Intermediate-energy cutoff BL Lac/blazar
LINER	Low-ionization nuclear emission-line regions
LLAGN	Low-luminosity AGN
LBL/LSP	Low-energy cutoff BL Lac/blazar
LDQ	Lobe-dominated quasar
LEG	Low-excitation galaxy
LPQ	Low polarization quasar
NLAGN	Narrow-line AGN, $\text{FWHM} \lesssim 1,000 \text{ km s}^{-1}$
NLRG	Narrow-line radio galaxy
NLS1	Narrow-line Seyfert 1
OVV	Optically violently variable (quasar)
Population A	
Population B	
Radiative-mode	
RBL	Radio-selected BL Lac
Sey1.5	Seyfert 1.5
Sey1.8	Seyfert 1.8
Sey1.9	Seyfert 1.9
SSRQ	Steep-spectrum radio quasar
USS	Ultra-steep spectrum source
XBL	X-ray-selected BL Lac
XBONG	X-ray bright optically normal galaxy

The top part of the table relates to major/classical classes. See Padovani et al. (2017) for a more complete version of this table, including more details and references.

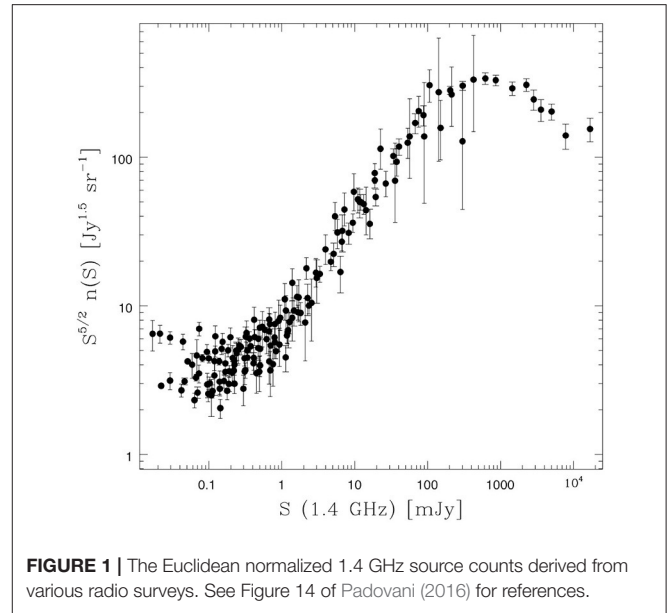


FIGURE 1 | The Euclidean normalized 1.4 GHz source counts derived from various radio surveys. See Figure 14 of Padovani (2016) for references.

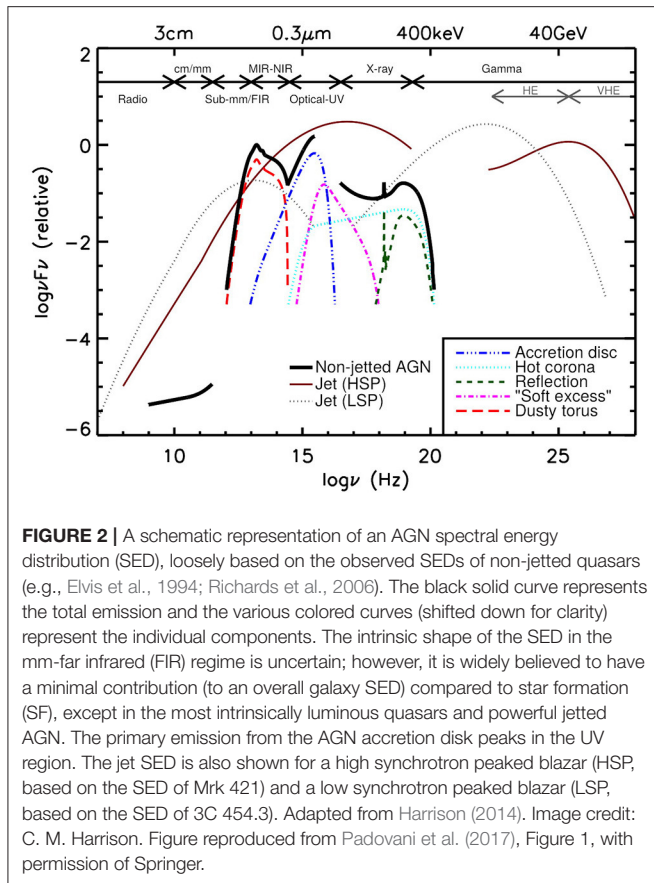
2.1. The Bright Radio Sky: $f_r \gtrsim 1 \text{ mJy}$

Sources include mostly jetted AGN, mainly blazars and RGs. Selection is done by just observing the high Galactic latitude sky as AGN are (basically) the only sources. This is helped by the fact that stars are extremely weak radio emitters. For example, out of the 527 sources with 5 GHz flux density $> 1 \text{ Jy}$ and Galactic latitude $|b_{\text{II}}| \geq 10^\circ$ (Kühr et al., 1981) only M 82 is not an AGN (and only M 82 and NGC 1068 do not belong to the RG, radio quasar, or blazar classes; moreover, $\sim 51\%$ of the classified sources are blazars). The radio band probes the jet and its emission is due to synchrotron radiation (ultra-relativistic electrons in a magnetic field). The only bias is that we are sampling the jetted AGN population, which is only a small fraction ($< 10\%$) of the total.

2.2. The Faint Radio Sky: $f_r \lesssim 1 \text{ mJy}$

Sources include both non-jetted AGN and a quickly decreasing fraction of jetted AGN (see Figure 7 of Padovani, 2016); the former are the dominant type. Selection requires data in various bands to single out the AGN, especially the non-jetted ones, from the SFGs, as the optical counterparts are very faint (as detailed in section 5.1 of Padovani, 2016). Apart from probing the jet in jetted AGN, radio emission is mostly due to star formation (through synchrotron emission from relativistic plasma accelerated in supernova remnants) in non-jetted ones (at least for radio-selected sources: see discussion in section 6.2 of Padovani, 2016). There is some chance of contamination from SFGs (especially if no X-ray detection is available). But we are now reaching the most common non-jetted AGN with no obscuration bias.

I would also like to stress, once more (see also Padovani, 2016, 2017), that the differences between jetted and non-jetted AGN are *not* taxonomic but reflect intrinsic differences, with jetted AGN emitting a large fraction of their energy in association



with powerful relativistic jets and therefore non-thermally, while the multi-wavelength emission of non-jetted AGN is dominated by thermal emission related to the accretion disk, which forms around the SMBH. Because of this, only jetted AGN manage to emit in the hard X-ray to γ -ray bands (see also **Figure 2**). Furthermore, the 50-year-old “radio-loud/radio-quiet” labels are obsolete, misleading, and wrong and should be dropped (Padovani, 2016, 2017).

3. THE INFRARED BAND

Whatever its detailed distribution and properties, we know there is dust around most AGN outside the accretion disk and on scales larger than those of the broad line region (BLR). This dust has a temperature in the 100–1,000 K range and is located at a minimum distance determined by the sublimation temperature of the dust grains (Barvainis, 1987). Ultraviolet (UV)/optical emission from the accretion disk is absorbed by it and re-emitted in the infrared (IR) band where it dominates the AGN spectral energy distribution (SED) at $\lambda \gtrsim 1 \mu\text{m}$ up to a few tens of micron (**Figure 2**).

Dust plays a vital role in AGN unification schemes (e.g., Antonucci, 1993; Urry and Padovani, 1995). Thanks to polarization studies it was in fact realized that the difference between type 1 (broad-lined) and type 2 (narrow-lined) AGN was solely due to orientation with respect to the dust. In the latter

objects our view of the accretion disk and the BLR is obscured by the dust and therefore we cannot see the UV bump and the broad lines typical of type 1 AGN but can only detect the narrow lines emitted by slower-moving clouds beyond the dust (but see Elitzur and Netzer, 2016 for a discussion about possible *real* type 2 AGN where the difference is not caused by dust obscuration; see also section 5.3 of Padovani et al., 2017).

Importantly, it now looks like the dust and the BLR are only present at high powers ($\gtrsim 10^{42} \text{ erg s}^{-1}$)/high Eddington ratios ($L/L_{\text{Edd}} \gtrsim 0.01$; see discussion in Padovani et al., 2017), which implies that dust-driven unification breaks down below these values. Jet-driven, low-power unification (linking BL Lacs with LEG RGs) is unaffected by this.

Based on all of the above, AGN selected in the IR band include mostly non-jetted AGN (because low-power/low accretion rate jetted sources do not have any dust) of the radiative-mode type (i.e., with high accretion rates and L/L_{Edd}). The IR is sensitive to both obscured and unobscured AGN, providing an almost isotropic selection, and in particular to extremely obscured AGN (missed by optical and soft X-ray surveys). Selection is done by typically using IR colors with the aim of separating AGN from SFGs (see section 3.2 in Padovani et al., 2017, and specifically **Figure 5** and **Table 2**). While for shallow surveys relatively high reliability and completeness can be obtained (see caption of **Table 2** for definitions) this is not the case for deeper ones, where high reliability can only be obtained by having low completeness (in other words, one can select mostly AGN only by missing a large fraction of them above a given flux limit).

4. THE OPTICAL/UV BAND

Optical/UV emission in AGN comes from the accretion disk and the BLR. Because of the presence of dust discussed in section 3 one can detect this emission only if our line of sight is unobstructed (which happens only for specific orientations) and therefore only in unobscured sources. The optical/UV band, therefore, provides a very biased view of the AGN phenomenon, although it was also thanks to their strong optical/UV emission that AGN were mostly discovered in the past.

AGN selected in the optical/UV band, therefore, include unobscured sources mostly of the non-jetted type [as only a small fraction of jetted AGN (radio quasars) have also a standard accretion disk and a BLR]; in short, type 1 AGN. Predictably, this band misses lots of obscured AGN (the type 2's), although many of them are still selected through their narrow emission lines, and even the moderately obscured ones. Other biases are against low-luminosity AGN (where the host galaxy light swamps the AGN) and also AGN close to stellar loci (as stars are also strong optical/UV emitters) especially at $z \sim 2.6$ and 3.5.

The optical/UV band, however, makes up for these shortcomings in two ways: (1) by providing spectra which are vital to study AGN physics, e.g., the accretion disk, to estimate the mass of the central SMBH through “reverberation mapping”, and to study the AGN spectral diversity; (2) by supplying us with huge optical catalogs. More details on these topics can be found in section 4 of Padovani et al. (2017).

TABLE 2 | A multi-wavelength overview of AGN highlighting the different selection biases (weaknesses) and key capabilities (strengths).

Band	Type	Physics	Selection biases/weaknesses	Key capabilities/strengths
Radio, $f_r \gtrsim 1$ mJy	Jetted	Jet	Non-jetted sources	High efficiency, no obscuration bias
Radio, $f_r \lesssim 1$ mJy	Jetted and non-jetted	Jet and SF	Host contamination	Completeness, no obscuration bias
IR	Type 1 and 2	Hot dust and SF	Completeness, reliability, host contamination, no dust	Weak obscuration bias, high efficiency
Optical	Type 1	Disk	Completeness, low-luminosity, obscured sources, host contamination	High efficiency, detailed physics from lines
X-ray	Type 1 and (most) 2	Corona	Very low-luminosity, heavy obscuration	Completeness, low host contamination
γ -ray	Jetted	Jet	Non-jetted, unbeamed sources	High reliability
Variability	All (in principle)	Corona, disk, jet	Host contamination, obscuration, cadence and depth of observations	Low-luminosity

The definitions of some of the terms used in the bias and capability columns are as follows: Efficiency, ability to identify a large number of AGN with relative small total exposure times (this is thus a combination of the nature of AGN emission and the capabilities of current telescopes in a given band). Reliability, the fraction of sources that are identified as AGN using typical criteria that are truly AGN. Completeness: the ability to detect as much as possible of the full underlying population of AGN. Table reproduced from Padovani et al. (2017), Table 3, with permission of Springer.

5. THE X-RAY BAND

X-ray emission appears to be one of the defining features of AGN and therefore the X-ray band has proven to be very important for AGN studies. X-rays are deemed to be due to inverse Compton scattering of the accretion-disk photons by an atmosphere above the accretion disk (referred to as the “corona” and whose geometry is still unknown). In jetted AGN the X-rays can have a major contribution from the jet as well. The X-rays then interact with matter by being reflected, scattered, and absorbed by the accretion disk and/or the dust discussed in section 3. X-ray spectra are sensitive to all of these components and, in particular, to the amount of absorbing material, which means they can be also used to classify sources into absorbed (type 2) and unabsorbed (type 1). This is because lower energy X-rays are more easily absorbed than higher energy ones and so the shape of the spectrum depends on the column density N_H . When $N_H > 1.5 \times 10^{24} \text{ cm}^{-2}$ (in so-called Compton-thick [CT] sources) the source looks completely absorbed in the X-ray band.

X-ray selected AGN, then, include in theory all AGN. However, sources with progressively larger N_H will be systematically missed below an increasingly higher energy, until the CT value is reached when all AGN are undetectable in the X-ray band. Low-luminosity AGN with $L_x \lesssim 10^{42} \text{ erg s}^{-1}$ are also biased against as this is the power associated with host galaxy emission. For the same reason at very low soft X-ray fluxes ($f_{0.5-2\text{keV}} \lesssim 6 \times 10^{-18} \text{ erg cm}^{-2} \text{ s}^{-1}$) contamination from SFGs kicks in. Low-power RGs (i.e., of the LEG type) are also mostly missed since their X-ray jet emission is not very strong and they lack an accretion disk. More details on these topics can be found in section 5 of Padovani et al. (2017).

6. THE γ -RAY BAND

The γ -ray band is conventionally divided into the High Energy (HE) band, between 100 MeV ($2.4 \times 10^{22} \text{ Hz}$) and $\sim 100 \text{ GeV}$ ($2.4 \times 10^{25} \text{ Hz}$), and the Very High Energy (VHE) band, covering the $\sim 50 \text{ GeV}$ to $\sim 10 \text{ TeV}$ ($2.4 \times 10^{27} \text{ Hz}$) range. Different detectors operate in the two bands: in the former we have electron pair-conversion telescopes in space characterized by a very large field of view (FoV; thousands of square degrees) (e.g., AGILE and *Fermi*: Atwood et al., 2009; Tavani et al., 2009); VHE γ -rays, on the other hand, are detected by Imaging Atmospheric Cherenkov Telescopes and Extensive Air Shower observatories on the ground¹ (e.g., Cangaroo, Hess, Magic, Veritas, and HAWC: de Naurois and Mazin, 2015; Abeysekara et al., 2017).

γ -ray astronomy is still a relatively young branch so its number of sources is much smaller compared to the other bands. The Third *Fermi* source catalog (Acero et al., 2015) has detected 3,033 sources all-sky above 100 MeV and up to 300 GeV. AGN make up $\approx 60\%$, and possibly $\lesssim 90\%$ (including the still unclassified sources), of these. These include only jetted AGN, the large majority of them being blazars with only a handful of RGs. Therefore, the current γ -ray sky is quite similar to the radio-bright sky, which is also dominated by blazars (section 2.1). This is simply because both radio and γ -ray photons are sampling jet-related, non-thermal processes.

¹These instruments observe at ground level the particle showers that are produced by the interaction of VHE γ -ray photons with the top layers of the atmosphere through the Cherenkov light they create or via the detection of the charged particles in the shower.

The VHE sky is even more sparsely populated, as only ~ 200 sources have been detected at TeV energies². Of those $\sim 35\%$ are AGN, mostly blazars. Blazars, so far, make up $\sim 92\%$ of the extragalactic γ -ray sky, with the remaining fraction including LEG RGs ($\sim 6\%$) and SFGs ($\sim 2\%$).

γ -ray selected AGN, therefore, include only jetted AGN, mostly blazars. There is then an obvious bias against non-jetted AGN, which is simply due, in my opinion, to the fact that these sources lack the engine to produce γ -ray photons (although they could still be *very* weak γ -ray sources through proton-proton collisions [via $pp \rightarrow \pi^0 \rightarrow 2\gamma$: the so-called “pion decay”] thanks to their outflows: Wang and Loeb, 2016; Lamastra et al., 2017).

Although it is clear that γ -rays are produced by relativistic jets, the exact process through which this happens is still not understood. Most researchers favor leptonic processes, where the electrons in the jet inverse Compton scatter their own synchrotron photons (synchrotron self-Compton) or an external photon field (external inverse Compton). In hadronic scenarios, on the other hand, γ -rays are instead thought to stem from high-energy protons either losing energy through synchrotron emission or through pion decay. In the hadronic case blazars would also produce neutrinos (from charged pions decay) and possibly also cosmic rays becoming therefore multi-messenger sources (e.g., Padovani et al., 2016; Resconi et al., 2017).

7. PUTTING IT ALL TOGETHER

7.1. Making Order Out of Chaos: A Minimalistic Approach to AGN

Figure 2 brings home one of the main points of this paper: different AGN components emit in different bands and only by looking at the broad, multi-wavelength picture can we understand AGN. But different bands gives us also different perspectives and types of sources, which means we need to be fully aware of selection effects. The selection biases and key capabilities (i.e., the weaknesses and the strengths) of all bands discussed above are summarized in **Table 2**.

Based on our current understanding of AGN we can now look back at **Table 1** and see that the complexity it displays is only apparent. It has been known for quite some time that many of the different classes can be explained by taking orientation and the presence (or lack) of a relativistic jet into account. More recent evidence suggests that other parameters play a role, above all the accretion rate (or equivalently L/L_{Edd} : see section 8.1 of Padovani et al., 2017 for references). This can change the structure of the accretion flow and thus the SED shape. I am convinced that these three parameters (i.e., orientation, relativistic jet, and accretion rate) explain most of the AGN variety. For example, BL Lacs are LEG RGs with their jets pointing toward the observer and also the radiatively inefficient version (with lower accretion rate and L/L_{Edd}) of PSRQs. Additionally, possible second-order parameters include the galaxy environment (e.g., Chiaberge et al., 2015) and the host galaxy, which can also partially obscure the AGN (e.g., Buchner and Bauer, 2017).

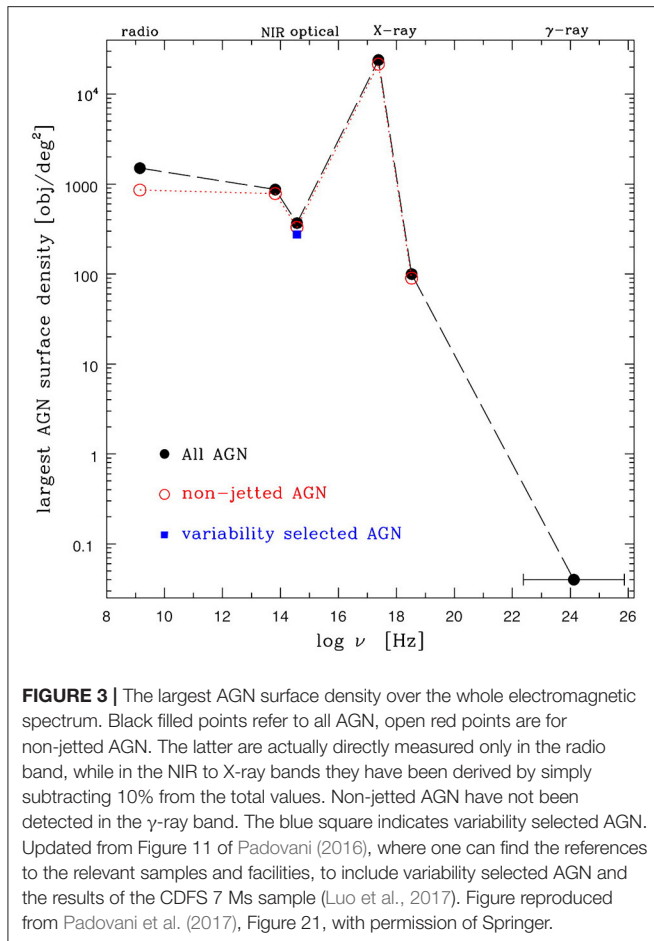
²<http://tevcat.uchicago.edu/>

7.2. AGN at All Frequencies

AGN emit over the full electromagnetic spectrum (and possibly even beyond it). The ease with which AGN are detected in the various bands, however, depends essentially on three aspects: (1) astrophysics. As shown by **Figure 2** AGN do not emit at the same level in all bands and the SED is shaped by the various AGN components. The most manifest of these is the presence or absence of a strong relativistic jet, which leads to the distinction between jetted and non-jetted AGN but also modifies the SED substantially (the latter class is weaker in the radio and not present in the γ -ray band). Other effects include changes in the accretion rate (or L/L_{Edd}), which can also modify the SED predominantly in the optical/UV and X-ray bands, and obviously obscuration by gas and dust that can absorb emission from the near-IR (NIR) to the soft X-rays; (2) selection effects. AGN selection techniques are not uniformly efficient in the various bands, resulting in (sometimes strong) biases. For example, the host galaxy in the optical, IR, and to some extent the radio band can be particularly luminous making the selection of faint AGN more challenging; host contamination is instead particularly low in the X-ray band; (3) technology. Not all astronomical detectors are equally efficient (it is much harder to catch a high-energy photon than a low-energy one) which means that observations in some wavebands are going to be more sensitive than others relative to the typical AGN SED. For example, contemporary radio telescopes can detect jetted AGN with much smaller bolometric fluxes compared to current γ -ray observatories.

This complex mix of physics, selection effects, and technology is behind the numbers in **Figure 3**, which shows the *largest* AGN surface density over the whole electromagnetic spectrum. Thanks to cutting-edge X-ray observatories and the low contamination from the host galaxy the AGN surface density is largest in the soft X-ray band. And the difficulty of detecting γ -ray photons combined with the fact that only a minority of AGN (the jetted ones) are γ -ray emitters result in a very low surface density in this band. Furthermore, despite being intrinsically radio faint, non-jetted AGN have a surface density in the radio band larger than that reached by the deepest optical surveys and at the same level as the NIR values, which highlights the sensitivity reached by present radio facilities. Since radio observations are unaffected by absorption they are also sensitive to all types of AGN, irrespective of their orientation (i.e., type 1s and type 2s), unlike soft X-ray ones.

Three more considerations (of the many more one could make!) are in order about **Figure 3**: (1) the actual number of *detected and identified* AGN has a wavelength dependence very different from that shown in the figure and is still heavily biased toward the optical/NIR bands, as most AGN were discovered through dedicated large-area spectroscopic surveys. The figure could then be thought of as describing the “detection potential” of the various bands; (2) the largest entry in the figure translates into *at least* ≈ 1 billion AGN in the Universe that could be detected with current technology. The comparison with the number of *currently known* AGN (of the order of a million: see **Figure 6** of Padovani et al., 2017) shows that there is still a lot of room for discovery in future AGN surveys (see section 8); (3) it is worth reflecting on the large financial and human investment behind



the figure, which could only be put together thanks to state-of-the-art ground- and space-based facilities (the ones listed in the caption of Figure 11 of Padovani, 2016 do not take into account the multi-wavelength data most of the surveys had to accumulate in order to be able to identify their targets) and the effort of many teams.

8. OPEN ISSUES AND THE NEAR FUTURE

We have learnt a lot about AGN since the discovery of the first quasar in 1963. However, there are still many open questions in AGN research, some of them quite important, to say the least, a comprehensive list of which is given in section 8.4 of Padovani et al. (2017). My favorite topics include:

- Why do a minority of AGN have jets? There are some hints, as jetted AGN appear to be more clustered, undergo mergers, reside in more massive, bulge-dominated galaxies (and perhaps spin faster) than non-jetted AGN. But the truth is this is still an unsolved issue.
- What is the composition, geometry, and morphology of the obscuring dust? Recent ground-based mid-IR interferometric observations have suggested that our “standard” (doughnut-like) picture of the so-called dusty torus might not be always valid and that a large fraction of the dust might instead reside

in the walls of the ionization cone (e.g., López-Gonzaga et al., 2016, and references therein).

- How does the cosmic history of black hole accretion as traced by AGN compare to the history of star formation in galaxies? More generally, what is the physical connection between SMBH evolution and that of their host galaxies and halos, and are these driven by common processes? This is a very hot topic, which has attracted a lot of attention in the past few years and has important implications for galaxy evolution. Despite this, we still do not have definite answers to these questions.
- Are blazars multi-messenger emitters? Said otherwise, is there a connection between γ -ray emission from jetted AGN, neutrinos and cosmic rays? If so, this would have huge implications for astro-particle physics, solving at the same time the mystery of the origin of (at least some of) the IceCube neutrinos and ultra high-energy cosmic rays detected, amongst others, by the Pierre Auger Observatory and the Telescope Array. It would also constrain theoretical models for particle acceleration in AGN by proving beyond any doubt the existence of very energetic protons.

We will soon have plenty of data to tackle these and other open issues. Here I simply list some of the main future facilities, which we will be having at our disposal in the next few years, sorted by band. Many more details and relevant hyperlinks can be found in Padovani et al. (2017).

- Radio: ASKAP (Australia), MeerKAT (South Africa), e-MERLIN (UK), APERTIF (The Netherlands), and finally the Square Kilometre Array;
- IR: JWST (NASA/ESA), Tokyo Atacama Observatory (Japan), Euclid (ESA/NASA), WFIRST (NASA), SPICA;
- Optical/NIR: Zwicky Transient Facility (USA), LSST, and the giant telescopes namely GMT, TMT, and the ELT;
- X-ray: eROSITA (Germany/Russia), XIPE, and Athena;
- γ -ray: Cherenkov Telescope Array and the Large High Altitude Air Shower Observatory (China).

In terms of AGN science these facilities will open up entire new regions of parameter space, especially with regard to sensitivity and number of sources. Just to give a few numbers: the Evolutionary Map of the Universe, one of the ASKAP surveys, will detect approximately 30 million AGN in the radio band; Euclid will provide NIR spectra for ≈ 1 million AGN; the LSST will select more than 10 million AGN; eROSITA will provide X-ray data for ≈ 3 million AGN; and the Cherenkov Telescope Array will detect ~ 10 times more blazars than are currently known at TeV energies.

In short, the future of AGN studies is very bright and we will soon be flooded with amazing new data. To take full advantage of them we need to ask the right questions and use the most appropriate and efficient tools.

9. MAIN MESSAGES

The main points of this paper can be thus summarized:

1. Different bands give us different perspectives, different physics, and different types of AGN: one needs to be aware of selection effects!

2. The “AGN zoo” is unnecessarily complex: most of the variety of AGN classes can be explained by three main parameters, namely orientation, presence or lack of relativistic jets, and accretion rate. Second-order parameters might include the environment and the host galaxy.
3. There are two main classes of AGN: jetted and non-jetted (not “radio-loud” and “radio-quiet”!).
4. In the next few years we will be flooded with AGN data. We need to be ready for them by: (1) asking the right questions; (2) having the right tools to analyze them.

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The author confirms being the sole contributor of this work and approved it for publication.

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