AGNfitter

An MCMC Approach to Fitting SEDs of AGN and galaxies

Gabriela Calistro Rivera
(Leiden Observatory / MPIA)

Elisabetta Lusso (INAF/MPIA), Joseph Hennawi (MPIA),
David W. Hogg (NYU)
Challenges of Studying AGN

**Galaxy vs. AGN**

- Both AGN and galaxies emit across the electromagnetic spectrum.
- Modelling their contributions implies handling a large parameter space.
Our Approach: SED Fitting
Our Approach: SED Fitting
Our Approach: SED Fitting

TYPE 1 - AGN

Image credit: W. Steffen (UNAM)

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XMM-COSMOS Survey Data

AGNfitter: models

TYPE 1 - AGN

Redshift $z = 1.371$

Accretion Disk (Big Blue Bump)

Cold Dust in Galaxy

Host Galaxy

Hot Dust (Torus)

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AGNfitter: models

Type 1 - AGN

Lusso et al. 2010, 2013

XMM-COSMOS Survey Data

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Accretion Disk (Big Blue Bump)

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AGNfitter: parameters

TYPE 1 - AGN

Accretion Disk (Big Blue Bump)

Hot Dust (Torus)

Host Galaxy

Cold Dust in Galaxy

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AGNfitter: parameters

**TYPE 1 - AGN**

**ACCRETION DISK**
(BIG BLUE BUMP)
(Richards+2006)
- Normalization par
- Reddening E(B-V)

**HOT DUST**
(TORUS)
(Silva+2004)
- Normalization par
- Column density Nh

**HOST GALAXY**
(Bruzual&Charlot 2003)
- Normalization par
- Age
- $\mathcal{T}$ (SFH Timescale)
- Reddening E(B-V)

**COLD DUST**
(STARBURST)
(Dale&Helou+2002)
- Normalization par
- Infrared luminosity

Lusso et al. 2010, 2013
AGNfitter: SED-Fitting with MCMC

- **Simulate** the parameters with random values
- Calculate Probability Density Functions **PDF**
  - Non-bayesian codes ($\chi^2$): Assume Gaussian
- Use of prior knowledge (luminosity functions, spectroscopic data, etc)

Bayesian SED fitting

Emcee (Foreman Mackey +13)

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AGNfitter: SED-Fitting with MCMC

- **Simulate** the parameters with random values
- Calculate Probability Density Functions PDF
- Non-bayesian codes ($\chi^2$): Assume Gaussian
- Use of prior knowledge (luminosity functions, spectroscopic data, etc)

Bayesian SED fitting
AGN\textit{filter} : Results

- 1 D and 2 D Posterior Density Functions of all parameters
- Proper calculation of uncertainties
AGNfitter: Results

- 1 D and 2 D Posterior Density Functions of all parameters
- Degeneracies are taken into account!
AGN filter: Results

XMM-COSMOS Survey Data

TYPE 1 - AGN

rest-frame wavelength $\lambda [\mu m]$

rest-frame frequency $\nu [Hz]$

XID=23, z = 0.378

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AGNfilter: Results

XMM-COSMOS Survey Data

TYPE 1 - AGN

rest-frame wavelength $\lambda [\mu m]$

$10^45$

$10^44$

$10^43$

rest-frame frequency $\nu [\text{Hz}]$

XID=23, $z = 0.378$

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AGNfitter: Applications
AGNfitter: AGN Classification (obscuration)

**Type 1**

**AGN classification**

**Standard approach:**
- Spectroscopy
- Color-color plots. Few bands approaches.

**Our approach:**

Multiwavelength classification through SED analysis

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AGNfilter : Results

XMM-COSMOS Survey Data

Sample of ~ 1800 sources ($Brusa^{+10}$)
X-ray selected AGN
Optically classified into Type 1 and Type 2

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**AGNfitter:** AGN Classification (obscuration)

- **$\log N_H$ (torus)**
- **$E(B-V)_{BBB}$**

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Type 1 AGN

Type 2 AGN

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**AGNfitter:** AGN Classification (obscuration)

Completeness: 86% and 70% for Type1 and Type2
Reliability: 80% and 77%

Many more applications...
AGNfitter: AGN Selection (in prep.)

Martin Hardcastle, Wendy Williams, Huub Röttgering, Kenneth Duncan, Matt Jarvis

Radio + I-band Selected Sample with LOFAR at 150 MHz
Wendy Williams et al. 2016

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AGNfitter: AGN Selection (in prep.)

![Graph showing AGN selection criteria using logarithmic scales for different luminosity ratios.]

- **AGN**
- **obscured**
- **pure**
- **SBandAGN**

Logarithmic scale for:
- $\log \left( \frac{L_{torus}}{L_{starburst}} \right)$ [1 - 40 $\mu$m]
- $\log \left( \frac{L_{bbb}}{L_{galaxy}} \right)$ [0.1 - 1 $\mu$m]
AGNfitter: AGN Selection (in prep.)

FIR - radio correlation
HERG - LERG properties

~ 1600 sources Böotes Field (LOFAR) radio selected Galaxies

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Conclusion

Probabilistic tool for SED analysis - AGNfilter (Python)

- Fully bayesian PDFs of AGN physical parameters
- Takes advantage of multi-core computing through multiprocessing.
- open-source, contributions are more than welcome!
Summary

- Multiple science applications for AGN filter
  - AGN obscuration
  - Galaxy – Nucleus Coevolution
  - Star formation in AGN
  - AGN Feedback

- AGN filter is now publicly available
  (ArXiv 1606.05648).