Change-Look AGN as a Challenger of AGN united model

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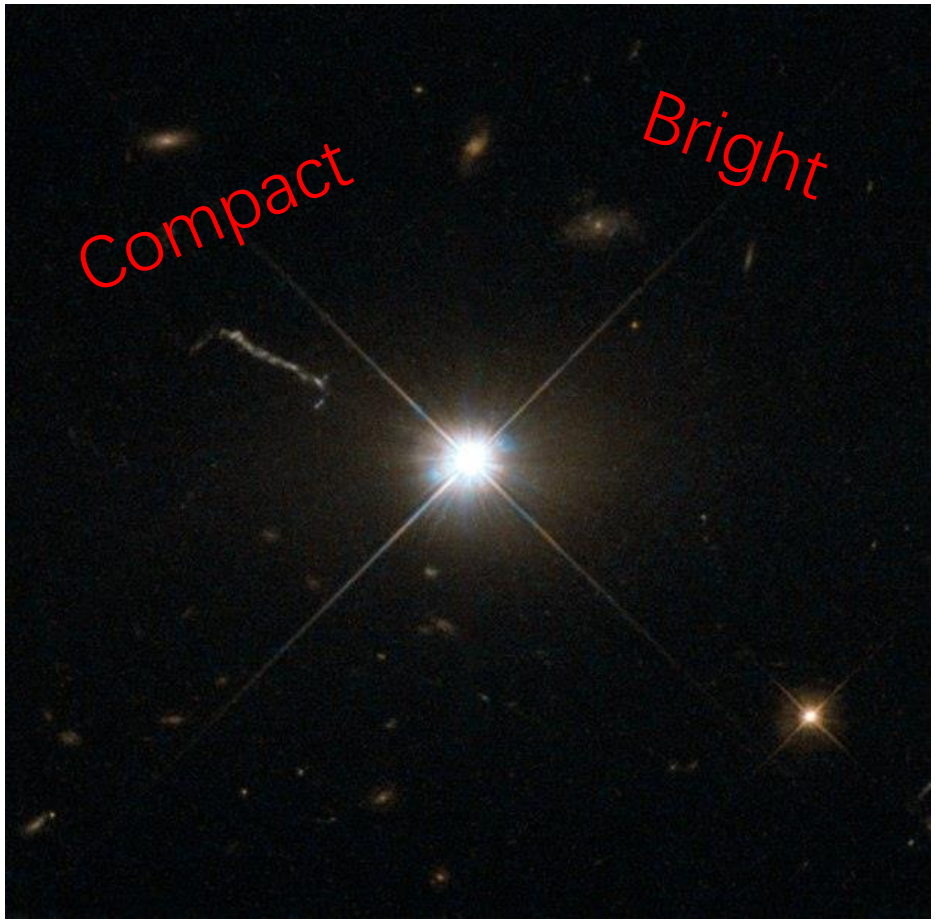
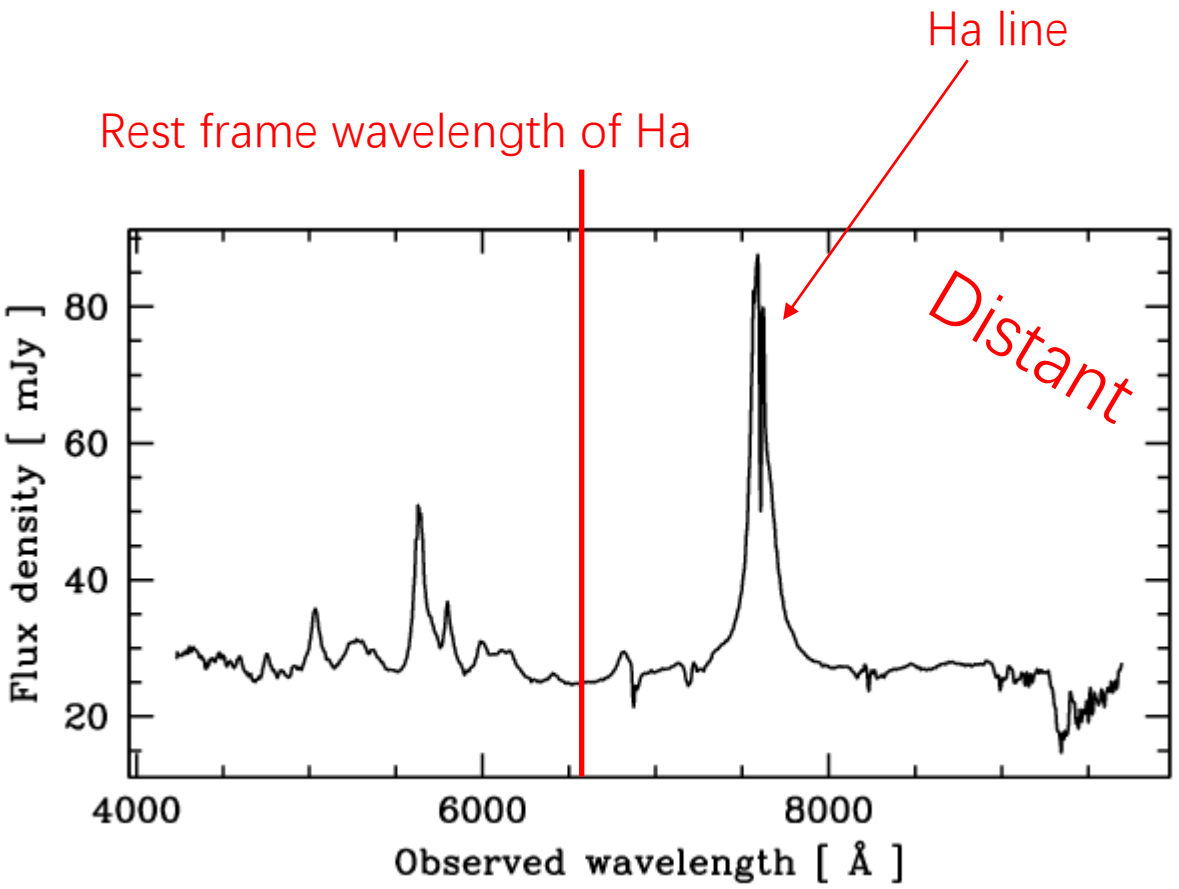
Outline

- AGN
- AGN united model
- Change-look AGN as a challenger

What is AGN?



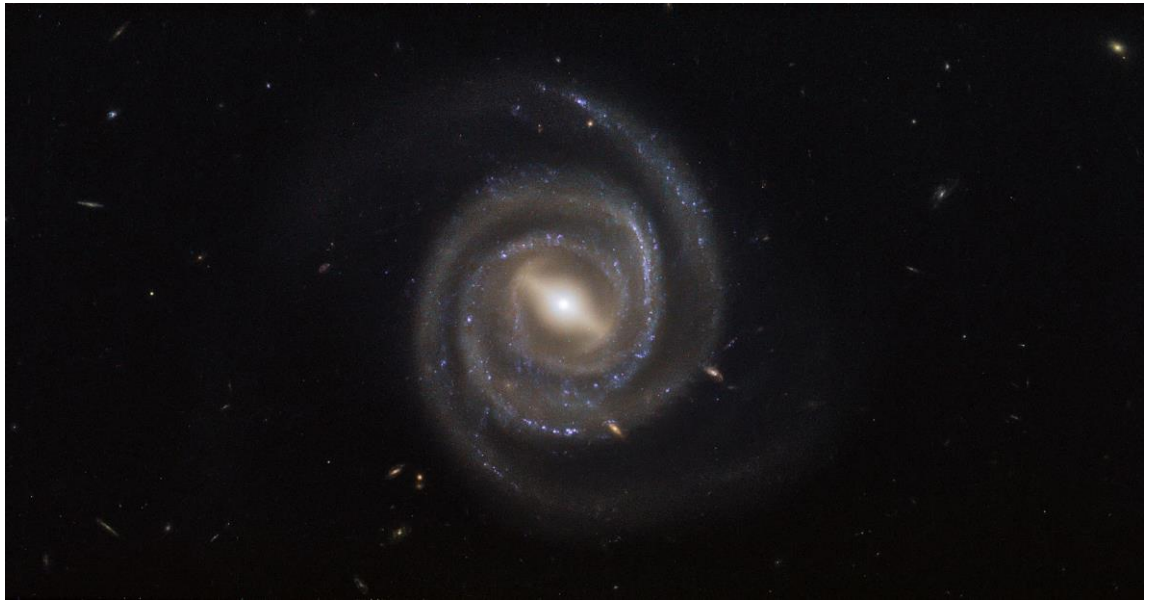
3C 273



Credits: https://en.wikipedia.org/wiki/File:Best_image_of_bright_quasar_3C_273.jpg http://isdc.unige.ch/3c273/

What is AGN?

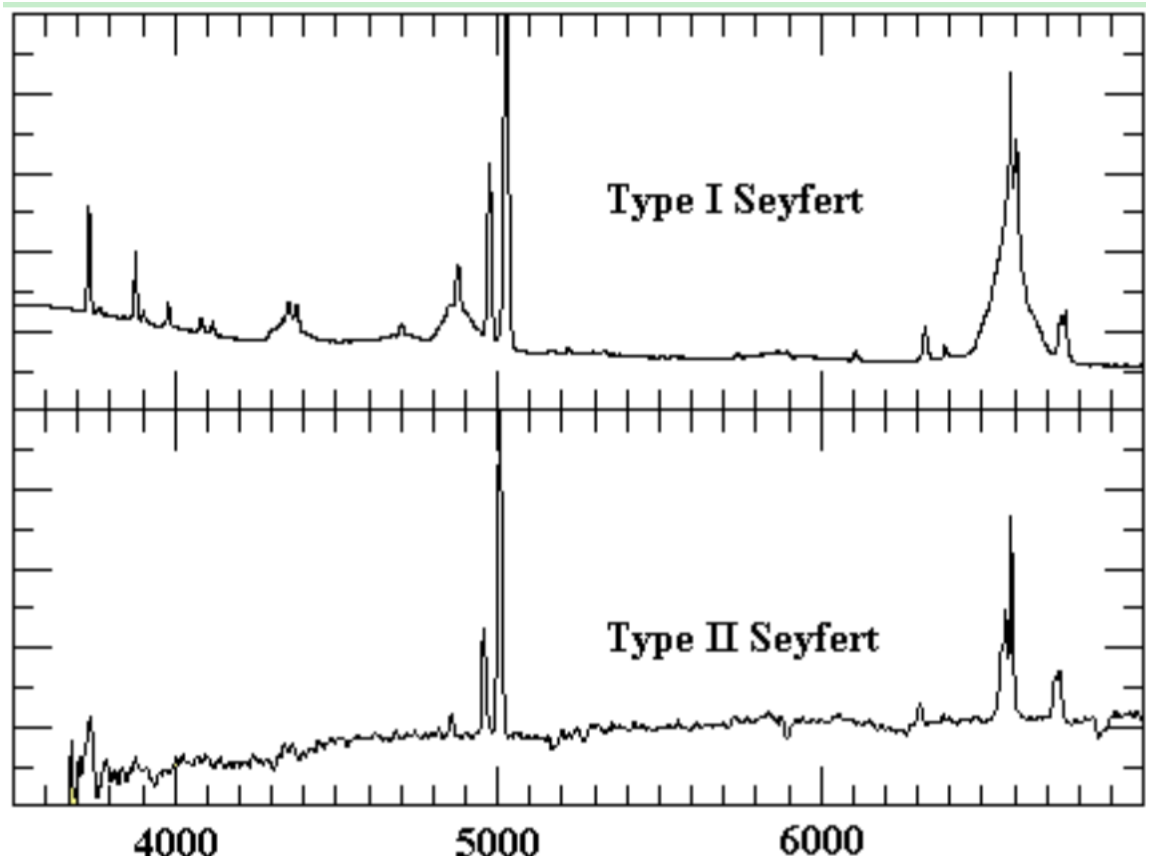
- **A**ctive **G**alactic **N**uclei
  - A **compact region at the center of a galaxy** that has a **much-higher-than-normal luminosity, which can not be totally produced by stars**.



https://en.wikipedia.org/wiki/Active_galactic_nucleus#/media/File:Lasers_and_supermassive_black_holes_UGC_6093.jpg

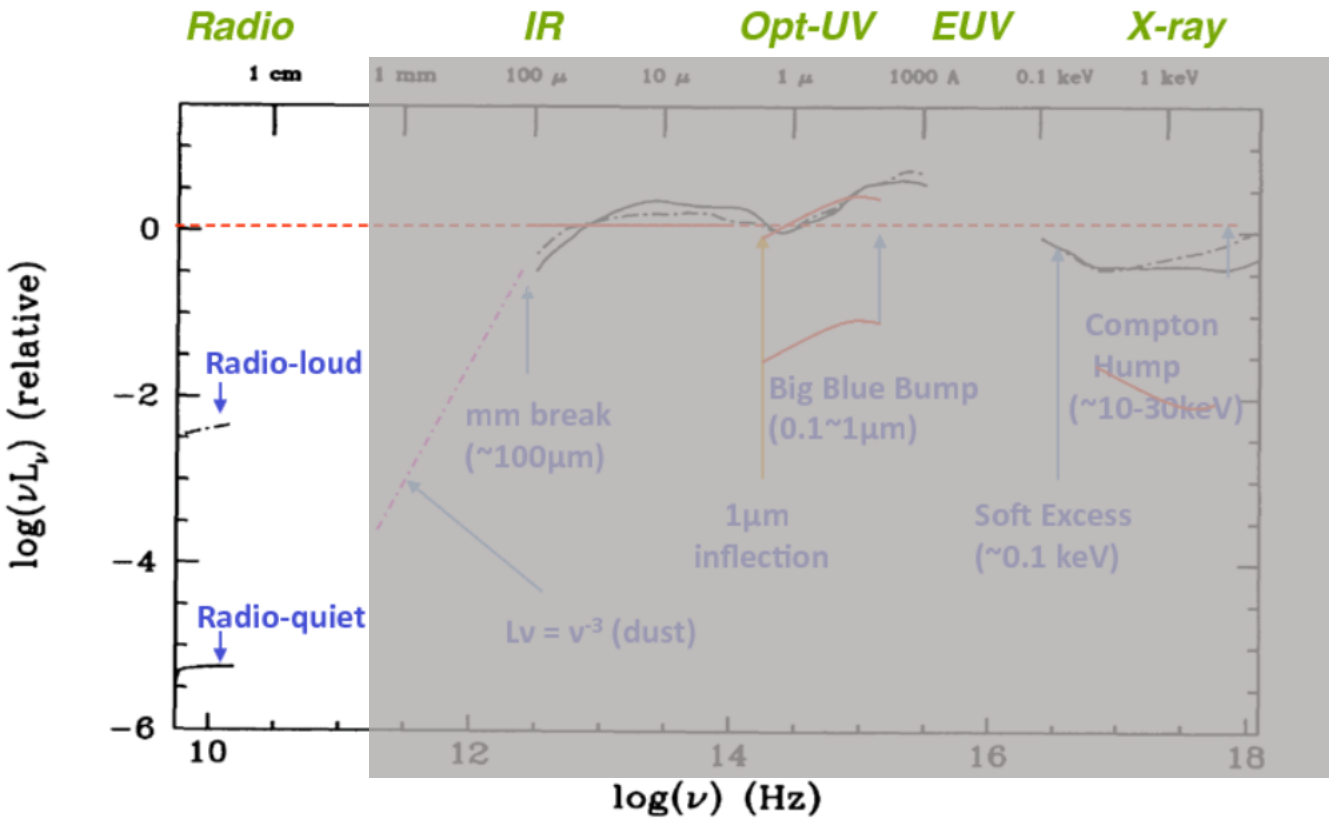
There are so many kinds of AGN

- We have seen Quasar, Center of active galaxy, they are very different in image.
- Some of them can only be separated by spectrum.
  - With broad line: Type I
  - Without broad line: Type II



There are so many kinds of AGN

- We have seen Quasar, Center of active galaxy, they are very different in image.
- Some of them can only be separated by spectrum.
- Some of them can only be separated by multiband observation:
  - Radio loud
  - Radio quiet



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

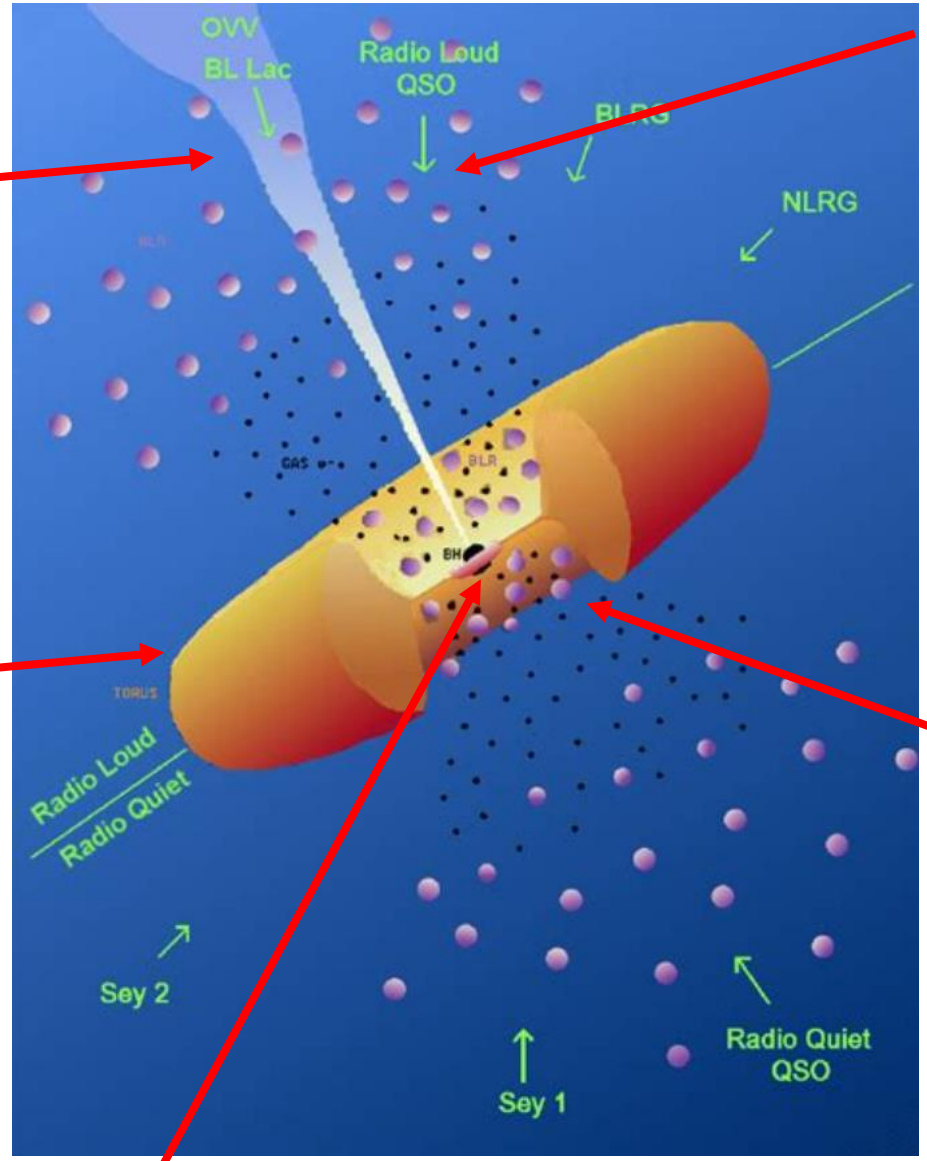
There are so many kinds of AGN

Class/Acronym	Meaning	Main properties/reference
Quasar	Quasi-stellar radio source (originally)	Radio detection no longer required
Sey1	Seyfert 1	FWHM $\gtrsim 1,000$ km s^{-1}
Sey2	Seyfert 2	FWHM $\lesssim 1,000$ km s^{-1}
QSO	Quasi-stellar object	Quasar-like, non-radio source
QSO2	Quasi-stellar object 2	High power Sey2
RQ AGN	Radio-quiet AGN	see ref. 1
RL AGN	Radio-loud AGN	see ref. 1
Jetted AGN		with strong relativistic jets; see ref. 1
Non-jetted AGN		without strong relativistic jets; see ref. 1
Type 1		Sey1 and quasars
Type 2		Sey2 and QSO2
FR I	Fanaroff-Riley class I radio source	radio core-brightened (ref. 2)
FR II	Fanaroff-Riley class II radio source	radio edge-brightened (ref. 2)
BL Lac	BL Lacertae object	see ref. 3
Blazar	BL Lac and quasar	BL Lacs and FSRQs
BAL	Broad absorption line (quasar)	ref. 4
BLO	Broad-line object	FWHM $\gtrsim 1,000$ km s^{-1}
BLAGN	Broad-line AGN	FWHM $\gtrsim 1,000$ km s^{-1}
BLRG	Broad-line radio galaxy	RL Sey1
CDQ	Core-dominated quasar	RL AGN, $f_{\rm core} \geq f_{\rm ext}$ (same as FSRQ)
CSS	Compact steep spectrum radio source	core dominated, $\alpha_{\rm r} > 0.5$
CT	Compton-thick	$N_{\rm H} \geq 1.5 \times 10^{24}$ cm^{-2}
FR 0	Fanaroff-Riley class 0 radio source	ref. 5
FSRQ	Flat-spectrum radio quasar	RL AGN, $\alpha_{\rm r} \leq 0.5$
GPS	Gigahertz-peaked radio source	see ref. 6
HBL/HSP	High-energy cutoff BL Lac/blazar	$\nu_{\rm synch\ peak} \geq 10^{15}$ Hz (ref. 7)
HEG	High-excitation galaxy	ref. 8
HPQ	High polarization quasar	$P_{\rm opt} \geq 3\%$ (same as FSRQ)
Jet-mode		$L_{\rm kin} \gg L_{\rm rad}$ (same as LERG); see ref. 9
IBL/ISP	Intermediate-energy cutoff BL Lac/blazar	$10^{14} \leq \nu_{\rm synch\ peak} \leq 10^{15}$ Hz (ref. 7)
LINER	Low-ionization nuclear emission-line regions	see ref. 9
LLAGN	Low-luminosity AGN	see ref. 10
LBL/LSP	Low-energy cutoff BL Lac/blazar	$\nu_{\rm synch\ peak} < 10^{14}$ Hz (ref. 7)
LDQ	Lobe-dominated quasar	RL AGN, $f_{\rm core} < f_{\rm ext}$
LEG	Low-excitation galaxy	ref. 8
LPQ	Low polarization quasar	$P_{\rm opt} < 3\%$
NLAGN	Narrow-line AGN	FWHM $\lesssim 1,000$ km s^{-1}
NLRG	Narrow-line radio galaxy	RL Sey2
NLS1	Narrow-line Seyfert 1	ref. 11
OVV	Optically violently variable (quasar)	(same as FSRQ)
Population A		ref. 12
Population B		ref. 12
Radiative-mode		Seyferts and quasars; see ref. 9
RBL	Radio-selected BL Lac	BL Lac selected in the radio band
Sey1.5	Seyfert 1.5	ref. 13
Sey1.8	Seyfert 1.8	ref. 13
Sey1.9	Seyfert 1.9	ref. 13
SSRQ	Steep-spectrum radio quasar	RL AGN, $\alpha_{\rm r} > 0.5$
USS	Ultra-steep spectrum source	RL AGN, $\alpha_{\rm r} > 1.0$
XBL	X-ray-selected BL Lac	BL Lac selected in the X-ray band
XBONG	X-ray bright optically normal galaxy	AGN only in the X-ray band/weak lined AGN

If you are interested in AGN zoo, please check the review: *Active galactic nuclei: what's in a name? (P. Padovan + 2017)*

AGN United Model

- Scientists are always trying to find simple models for complex phenomena
- We have an united model for all kinds of AGNs



Narrow line region: ionized gas with low rotation velocity

Jet

Dust torus

Board line region: ionized gas with high rotation velocity

Super massive black hole and accretion disk

AGN United Model

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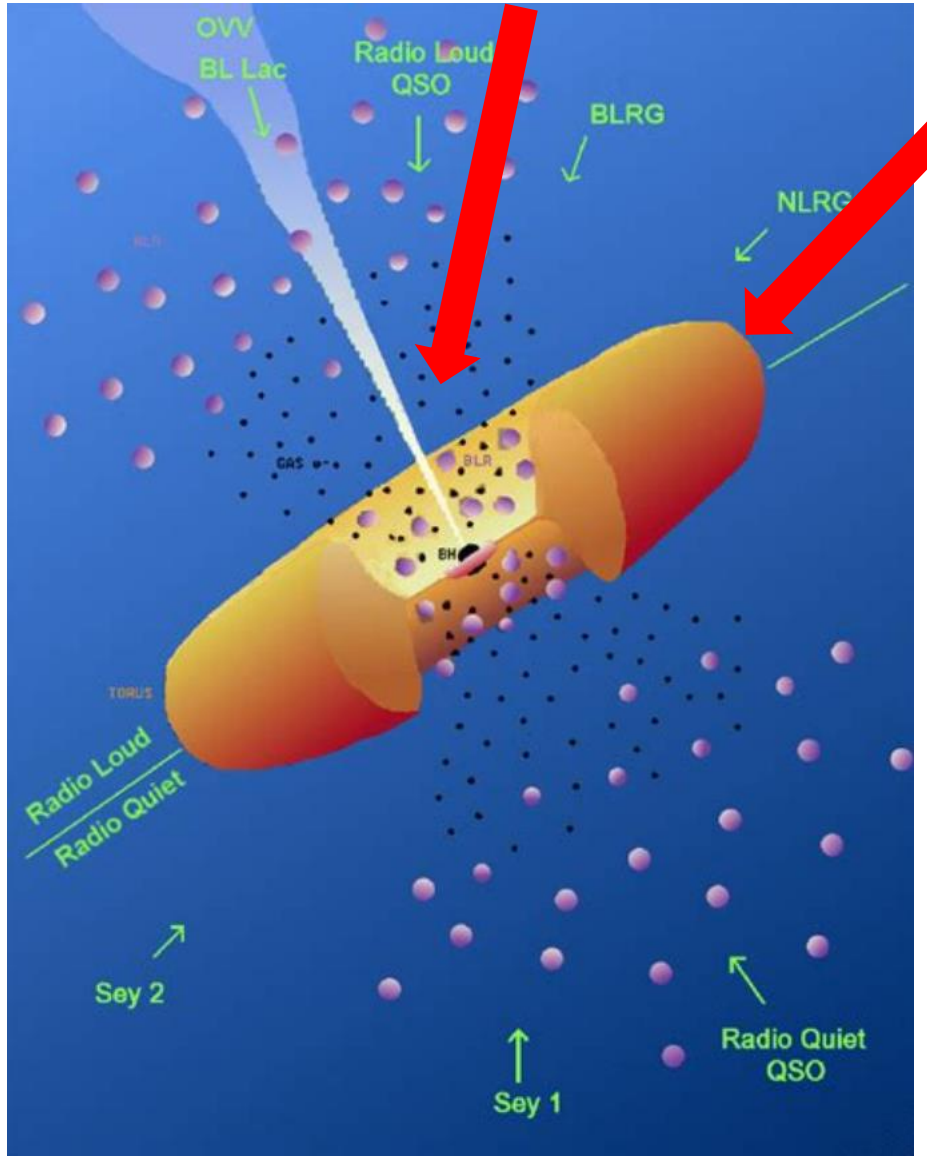
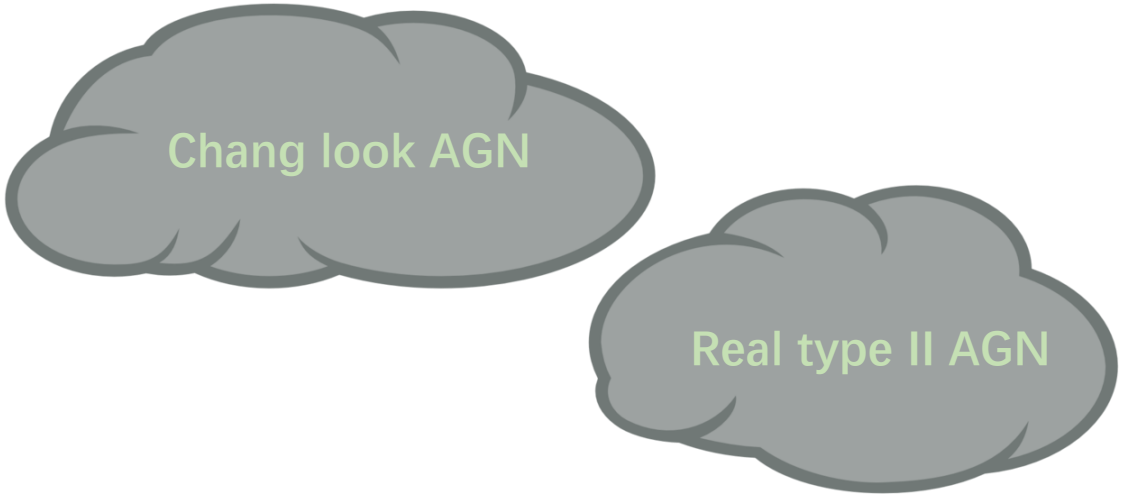


There are (at least) two dark clouds on the sky

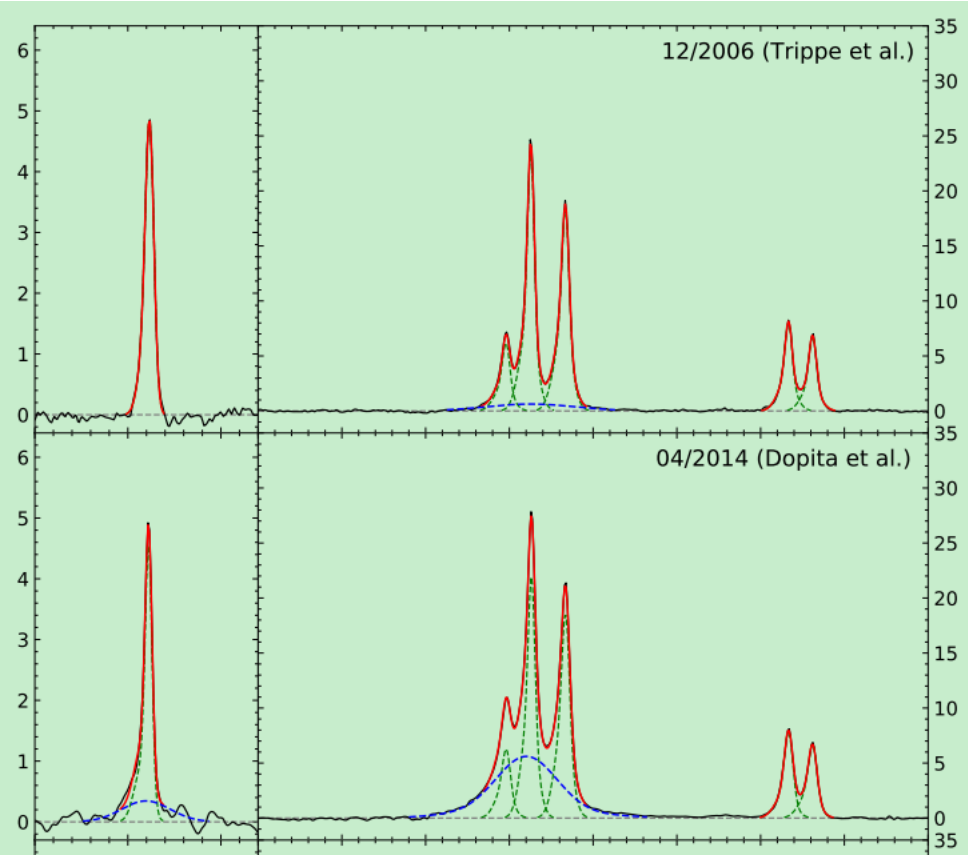


Take home messages

- Some of the change-look AGNs is hard to be explained under the united model
- An accretion mode related model could explain this kind of AGN

The Eddington ratio-dependent changing look events in NGC 2992 Muryel Guolo et. al. 2021

Change-look (变脸) AGN

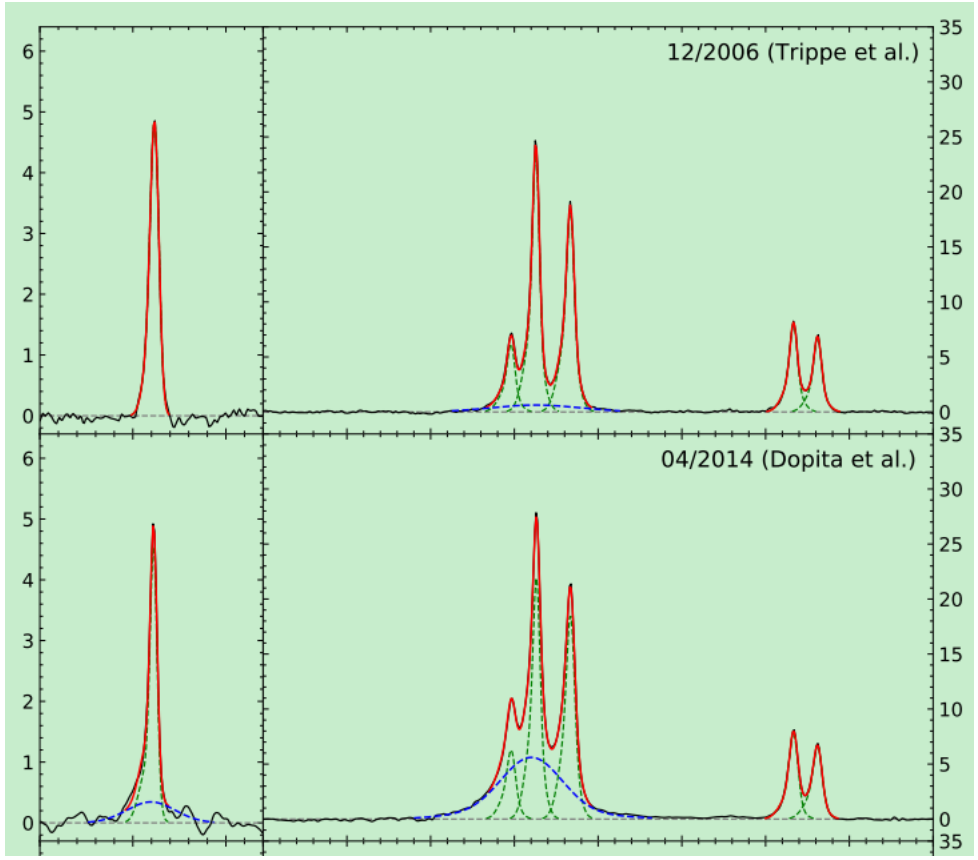


NGC 2991

Type II

Type I

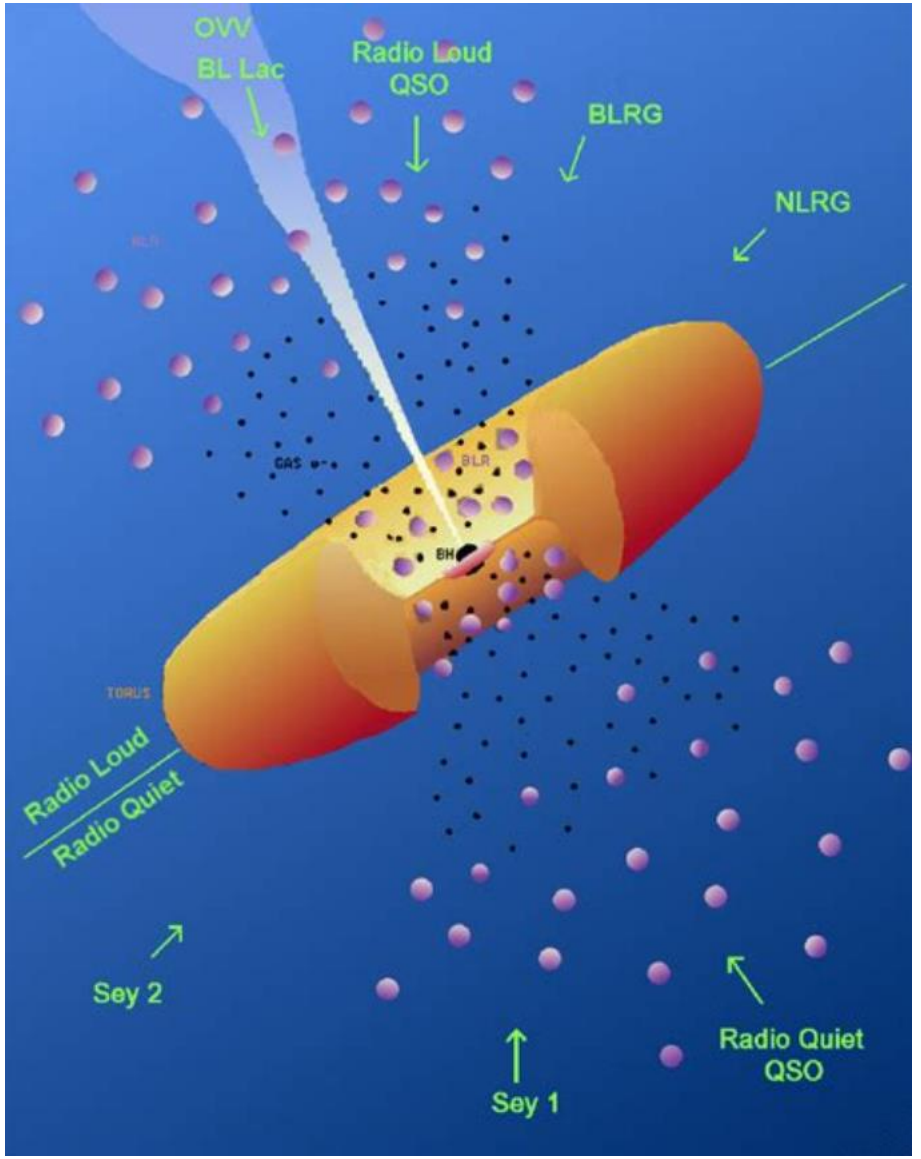
Change-look (变脸) AGN



NGC 2991

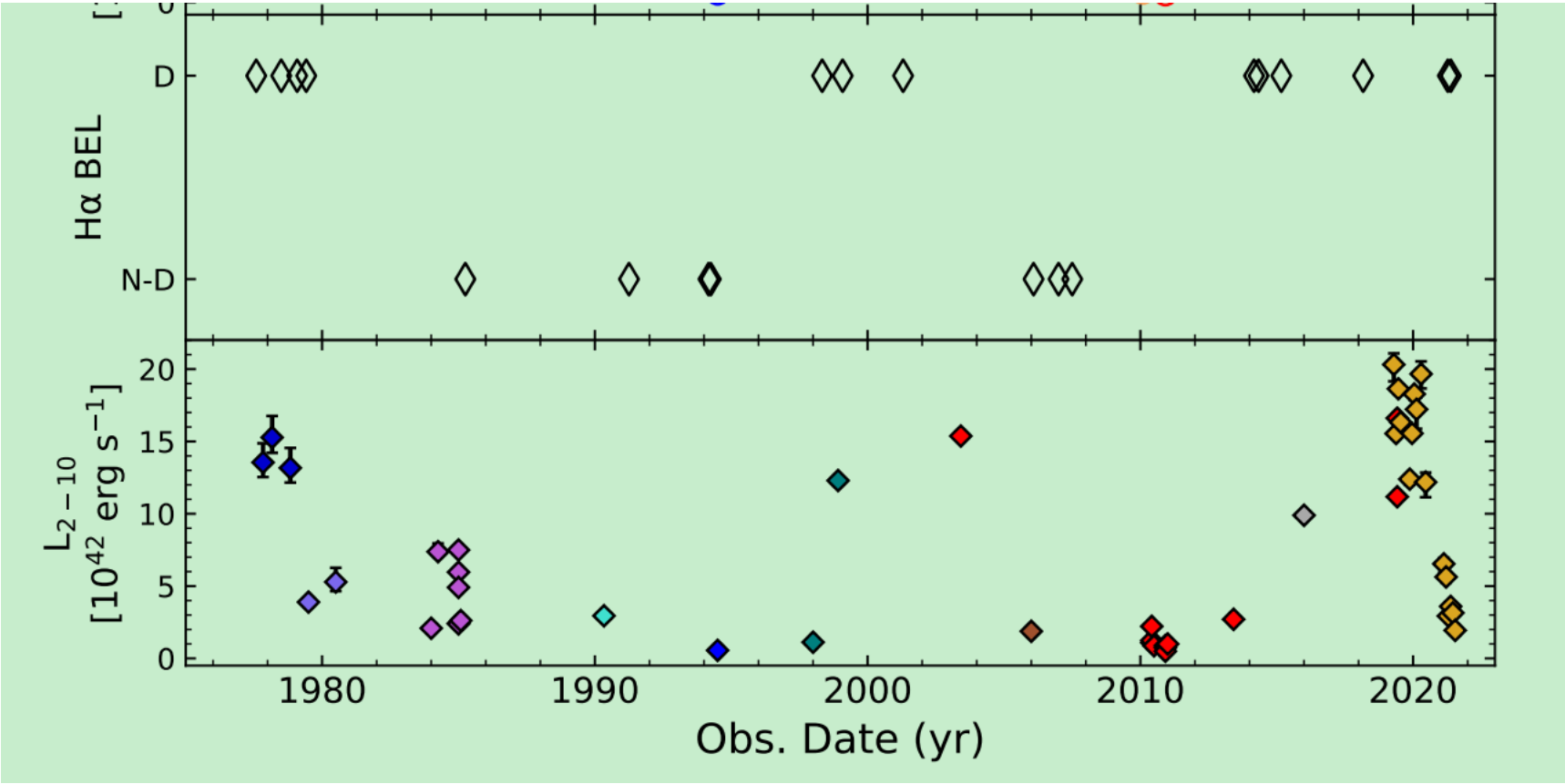
Type II

Type I



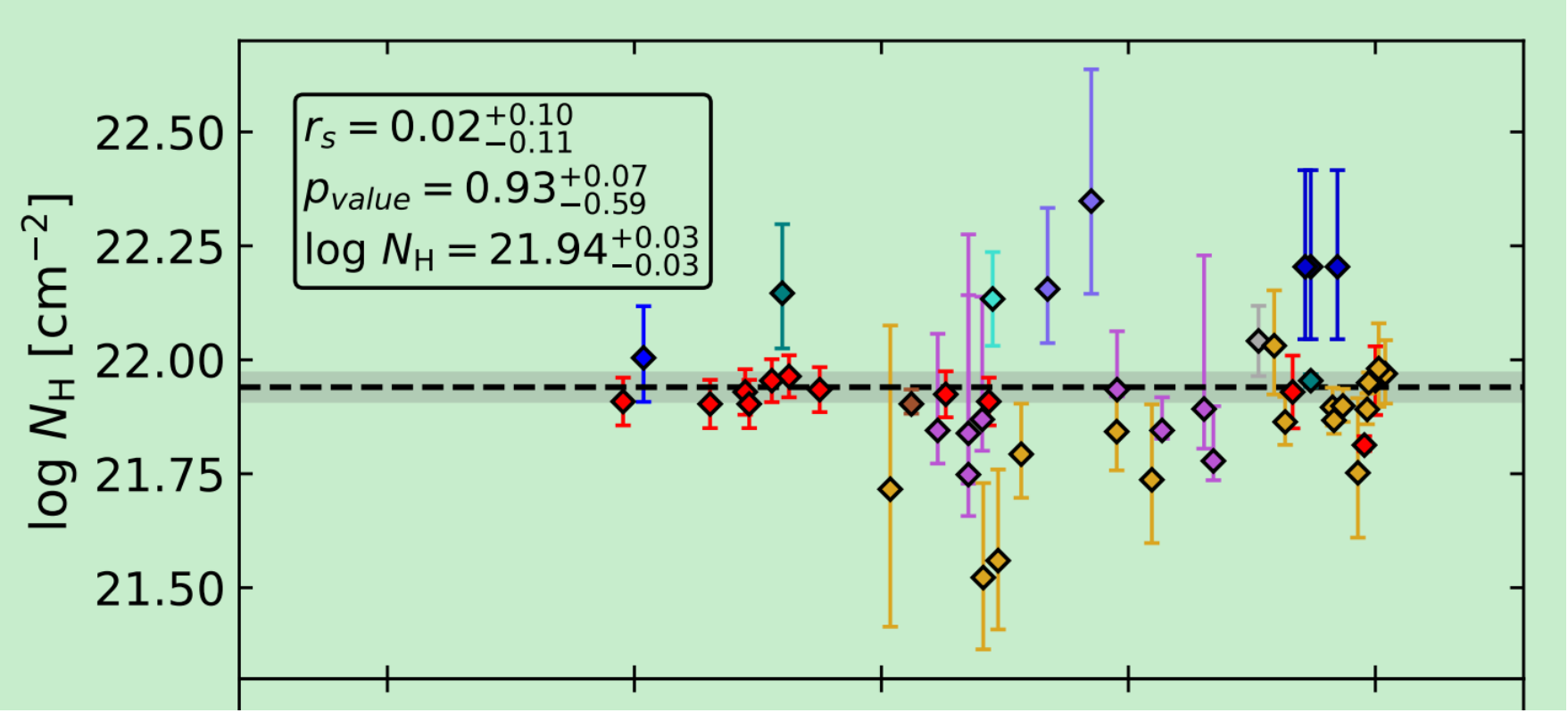
We need a new model…

- but wait, let's see observational properties for inspiration



We need a new model

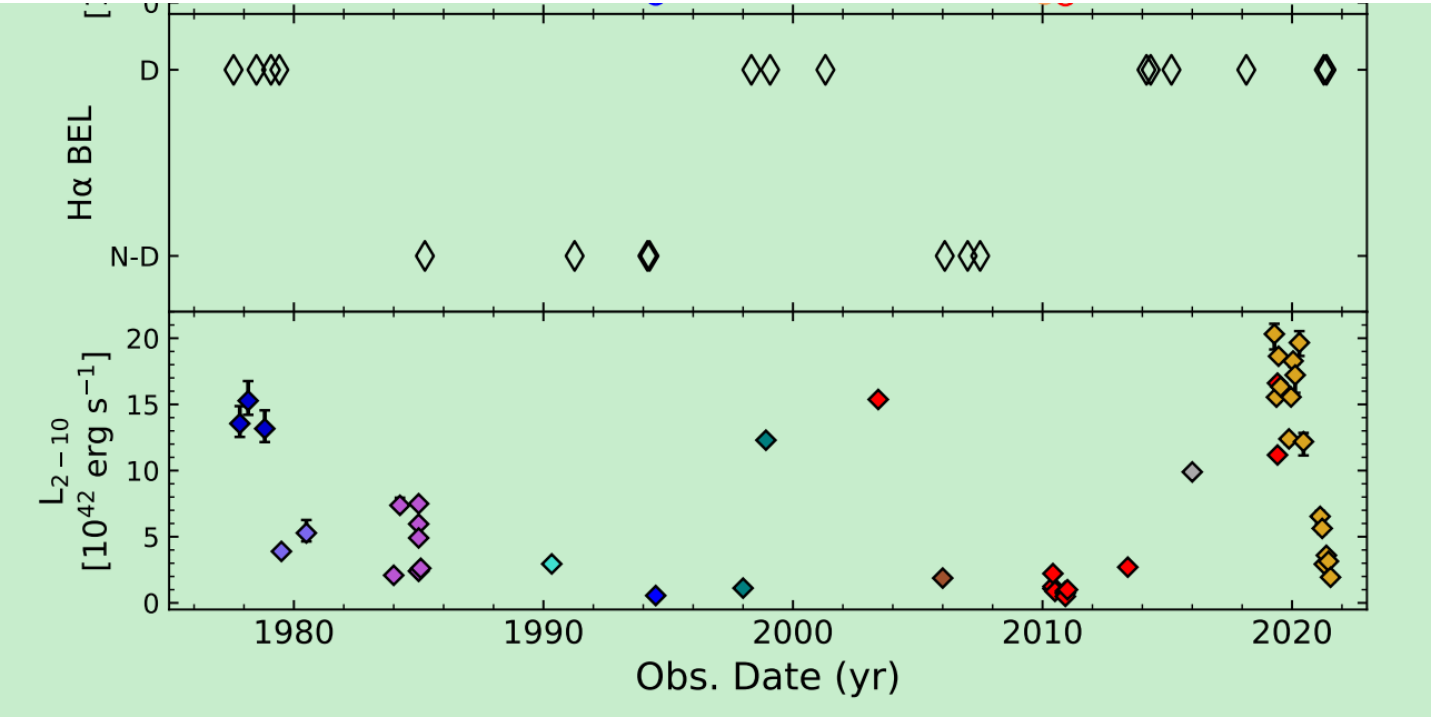
- Rotation of clumpy dust in torus?



X-ray luminosity

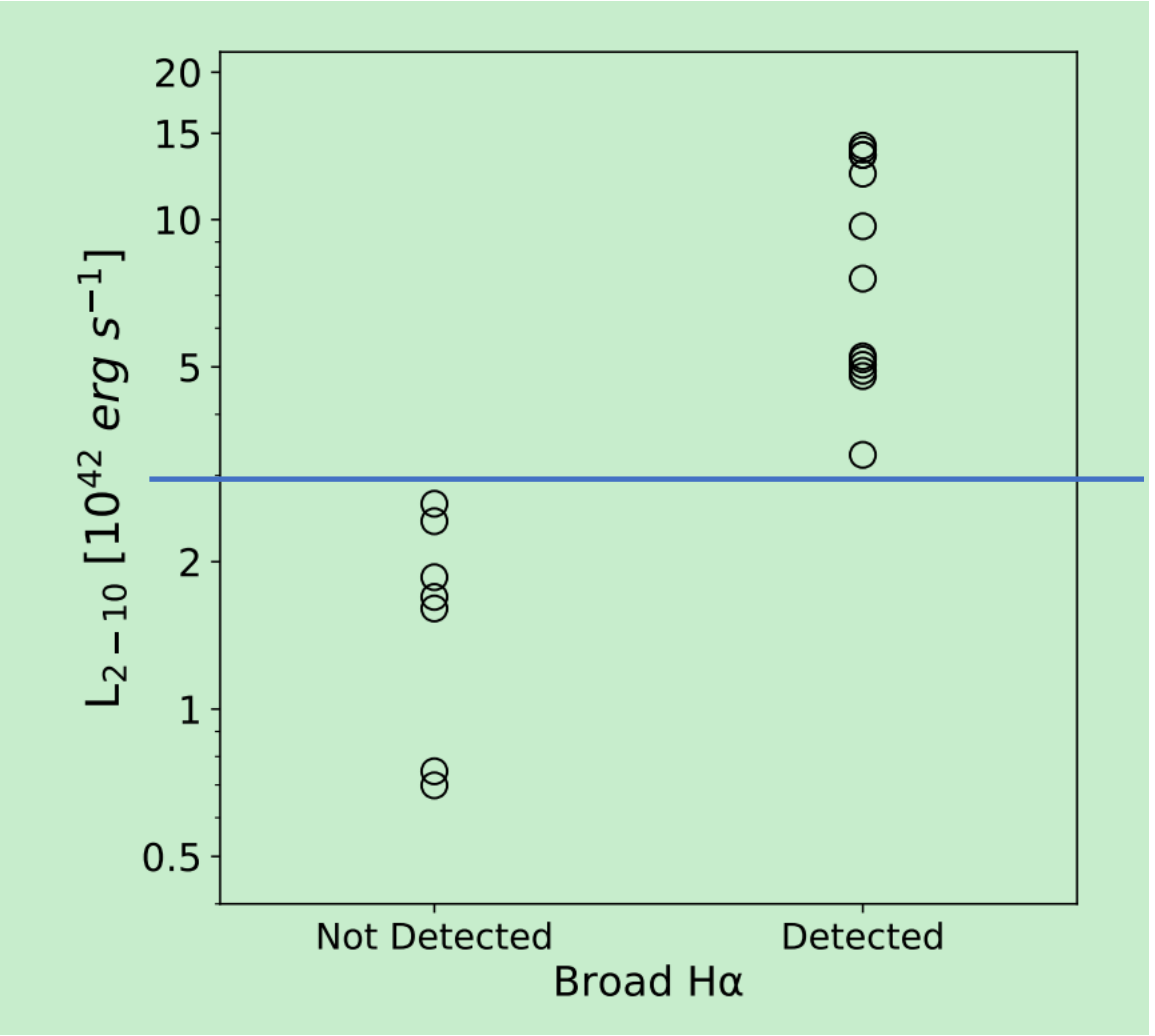
We need a new model

- Tidal Disruption Event (TDE)?
  - No, or we need 3 TDEs in 40 years



We need a new model

- The transition of accretion state
  - We have a critical value for type I and type II
  - This value is about 1% of Eddington ratio, which is the critical value between **radiatively inefficient accretion flow** and a **thin accretion disk**



The transition of accretion mode, so?

- **Radiatively inefficient accretion flow**
  - The dimming (brightening) of the AGN continuum luminosity, so no photons to ionize board line region.
  - Cloud flow rate is too low to sustain board line region.

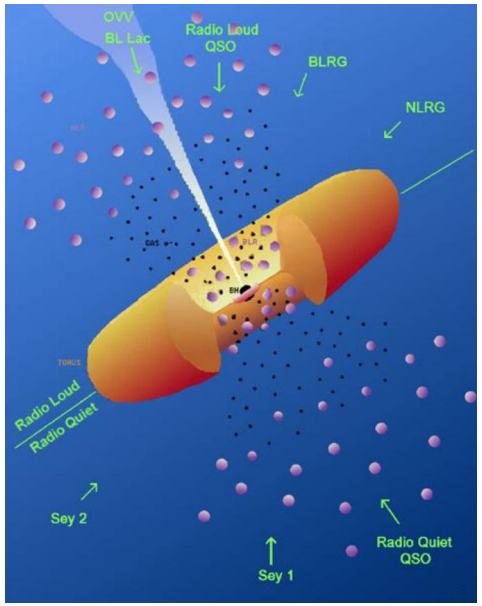
- These two scenarios can be separated by polarization observation according to simulation.

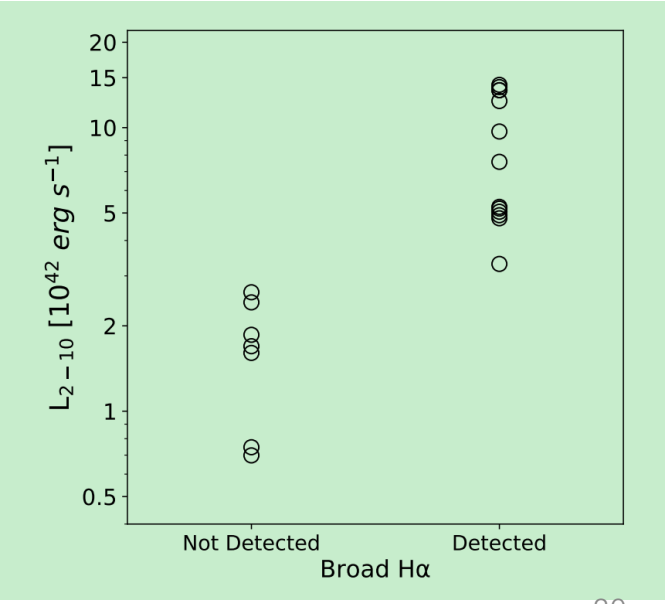
My comments

- The classical united model does not always work, but how about accretion rate related model?
  - There is no the accretion rate version of united model up to now.
- How about other change-look AGNs? All of them have same properties of this one?
- One model multi observations?

Summary

- There are so many kinds of AGNs in observation
- We have an united model for the majority of AGNs
- Chang-look AGN is a challenger of this united model
- Chang-look AGN NGC 2991 prefers an accretion mode transition model





Questions

- How about the mass of this AGN?

M_{BH}	Method	References
5.2×10^7 $M_\odot$	M_{BH}- σ_* (Tremaine et al. 2002)	Woo & Urry (2002) (σ_* = 158 km s^{-1})
$4.8^{+3.9}_{-2.4} \times 10^7$ $M_\odot$	M_{BH}- σ_* (Gültekin et al. 2009)	Nelson & Whittle (1995) (σ_* = 158 ± 13 km s^{-1})
$3.0^{+5.5}_{-1.5} \times 10^7$ $M_\odot$	σ^2_{rms}- M_{BH} (Ponti et al. 2012)	Marinucci et al. (2020)
$1.2^{+1.5}_{-0.7} \times 10^7$ $M_\odot$	$M_{SE}(\sigma_{H\beta}, L_{H\beta})$ (Dalla Bontà et al. 2020)	This Work (2006 spectra)
$1.3^{+3.8}_{-1.0} \times 10^7$ $M_\odot$		This Work (2014 spectra)
$3.5^{+9.1}_{-2.5} \times 10^7$ $M_\odot$		This Work (2015 spectra)
$2.4^{+3.2}_{-1.4} \times 10^7$ $M_\odot$		This Work (2018 spectra)
$2.5^{+2.7}_{-1.3} \times 10^7$ $M_\odot$		This Work (03/2021 spectra)
$2.2^{+2.3}_{-1.1} \times 10^7$ $M_\odot$		This Work (04/2021 spectra)

Questions

- Why does polarization observation distinguish these two models?
  - If BLR itself vanishes, the photon will not pass through these gas, it will change the property of polarization.
- Where does jet com from?
  - Not very clearly up to now, the big picture is that the magnetic field could extract rotation energy of BH or accretion disk to form jet.
- Why we believe the SMBH is the engine of AGN?
  - No other choices