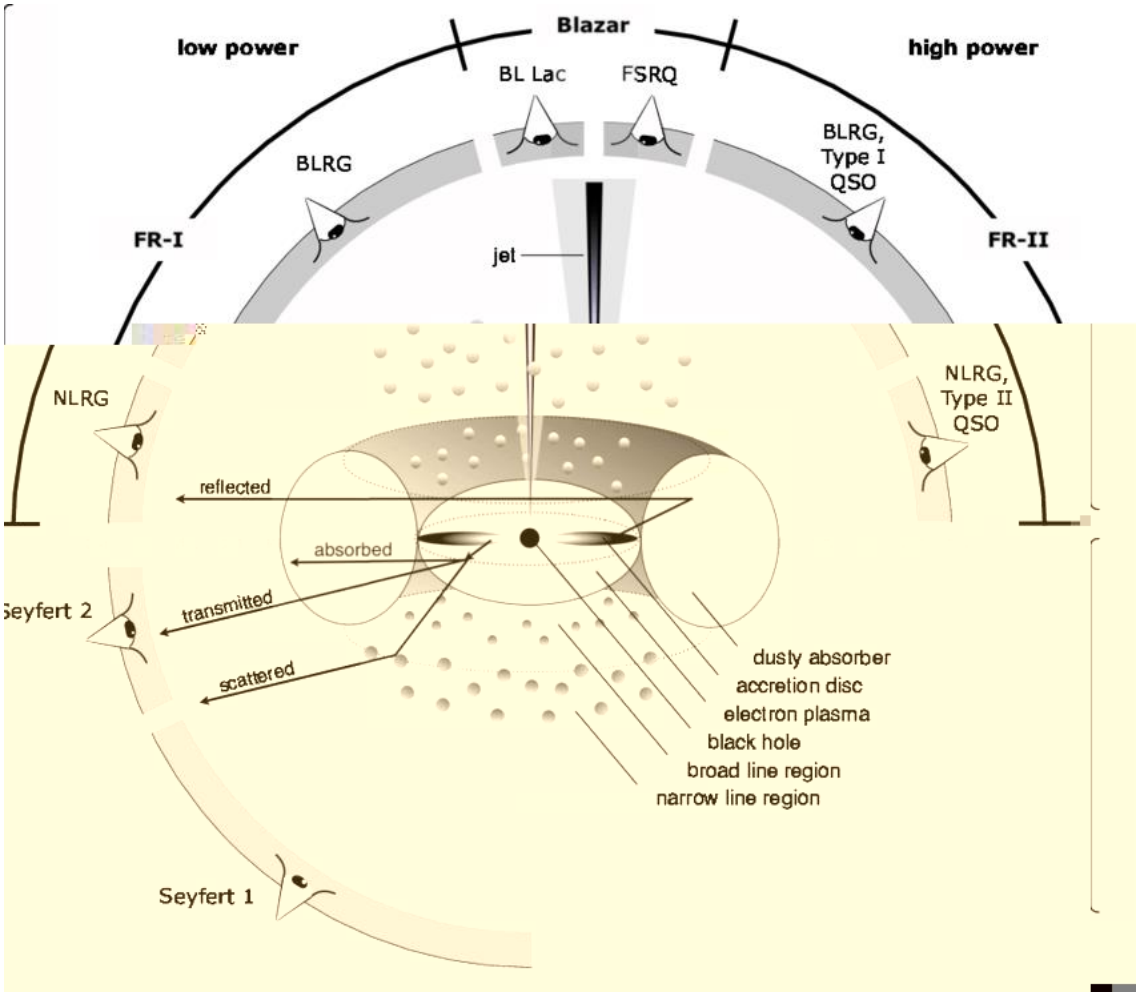
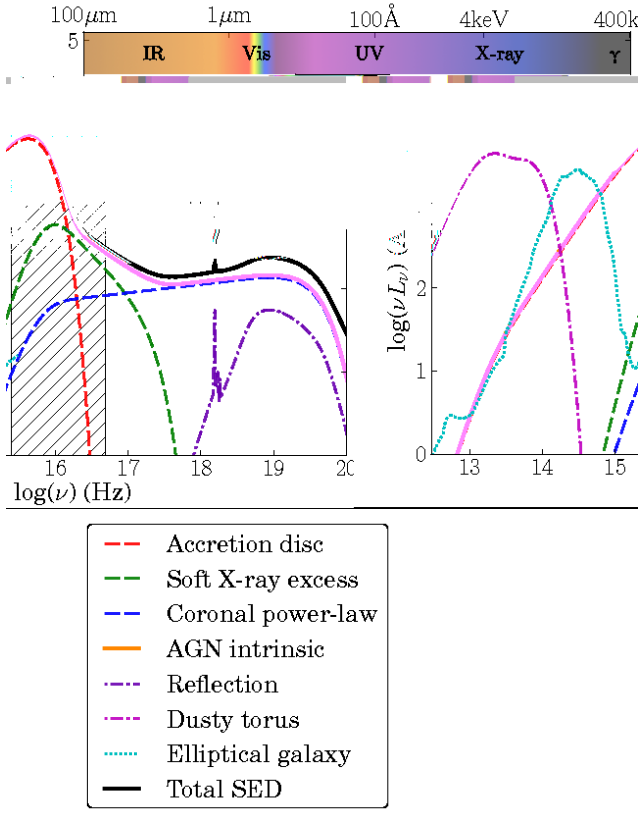
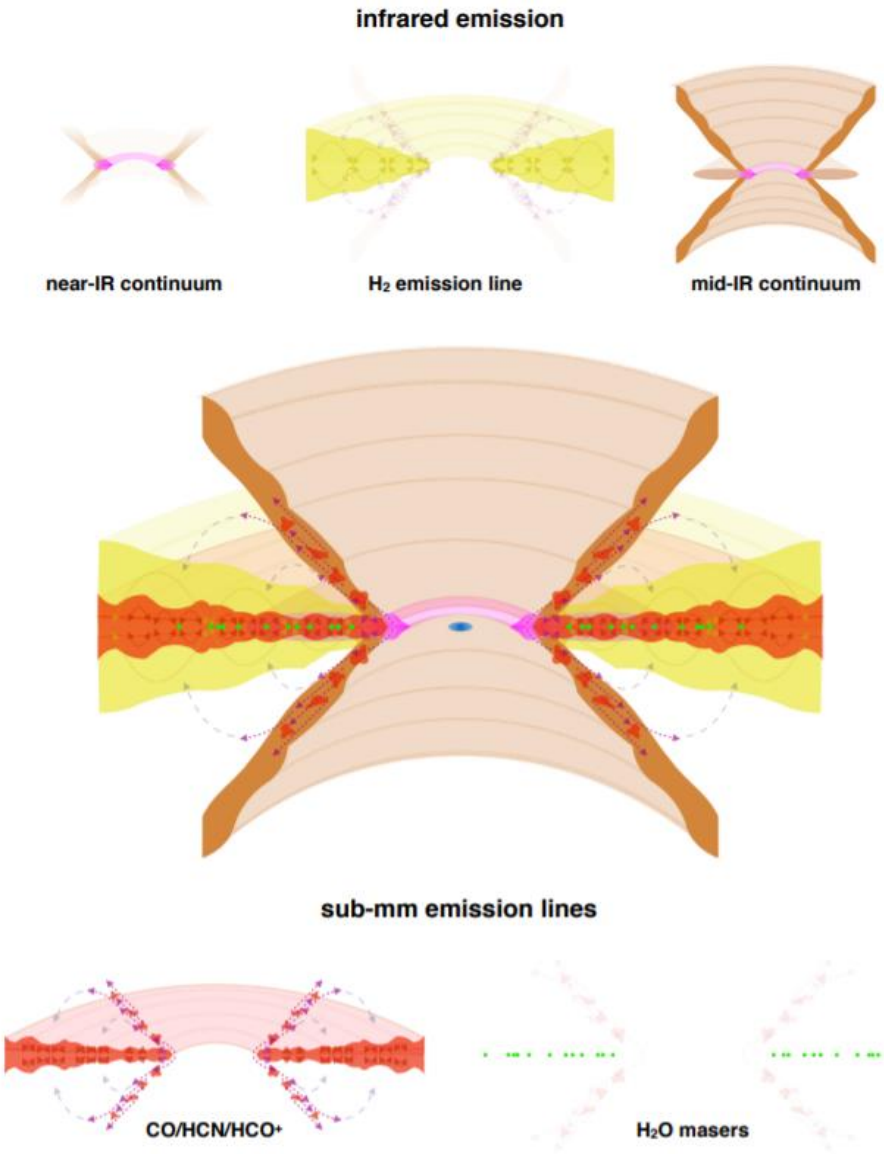
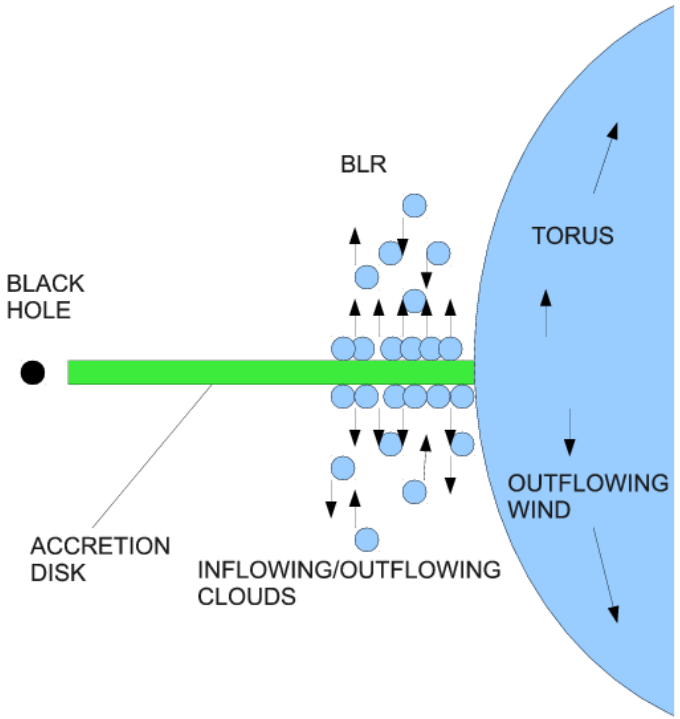
Type 1 AGN reverberation mapping in polarized light

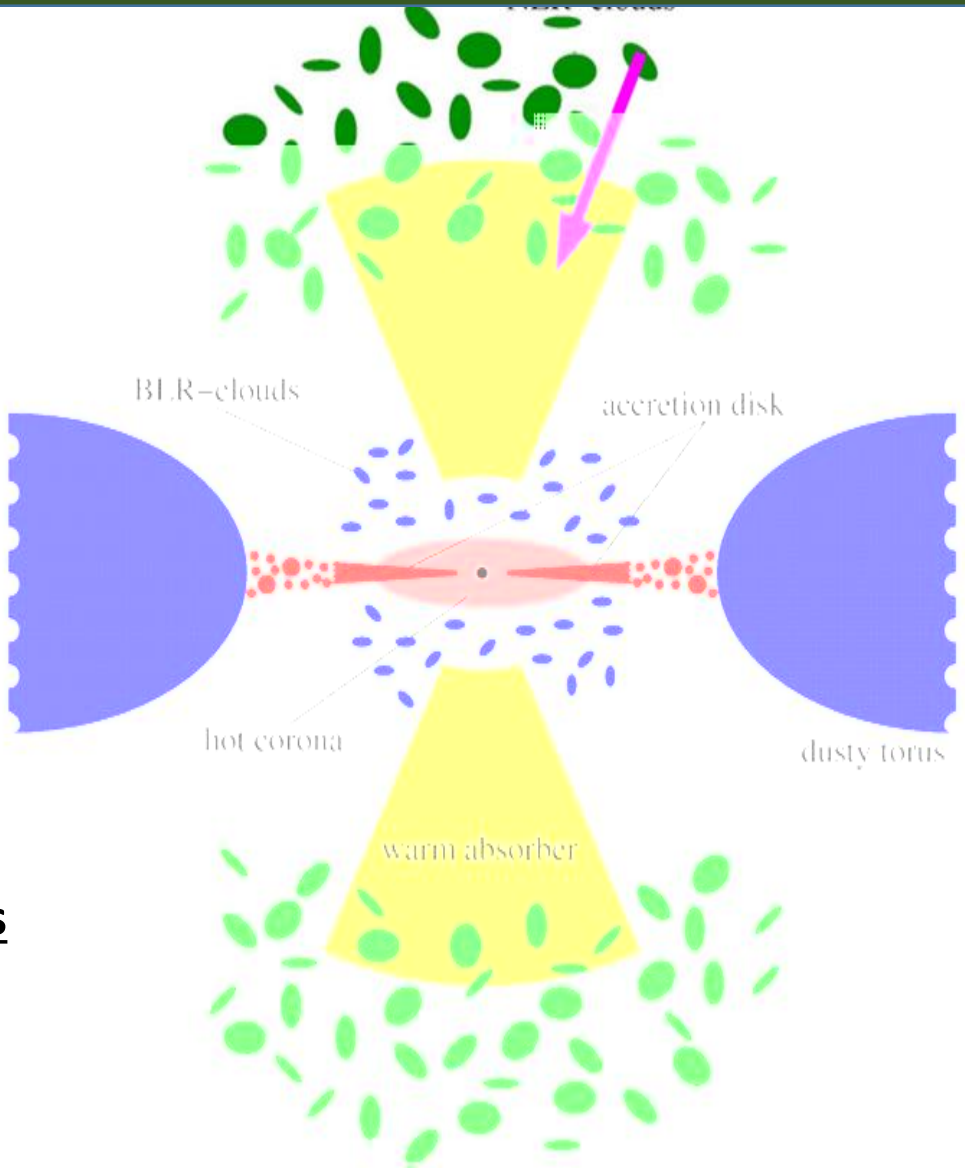




Torus is the key point of the UM!


infrared emission
near-IR continuum
H2 emission line
mid-IR continuum
sub-mm emission lines
CO/HCN/HCO+
H2O masers


BLR
TORUS
BLACK
HOLE
OUTFLOWING
WIND
ACCRETION
DISK
INFLOWING/OUTFLOWING
CLOUDS



- **Equatorial scattering by dusty torus**

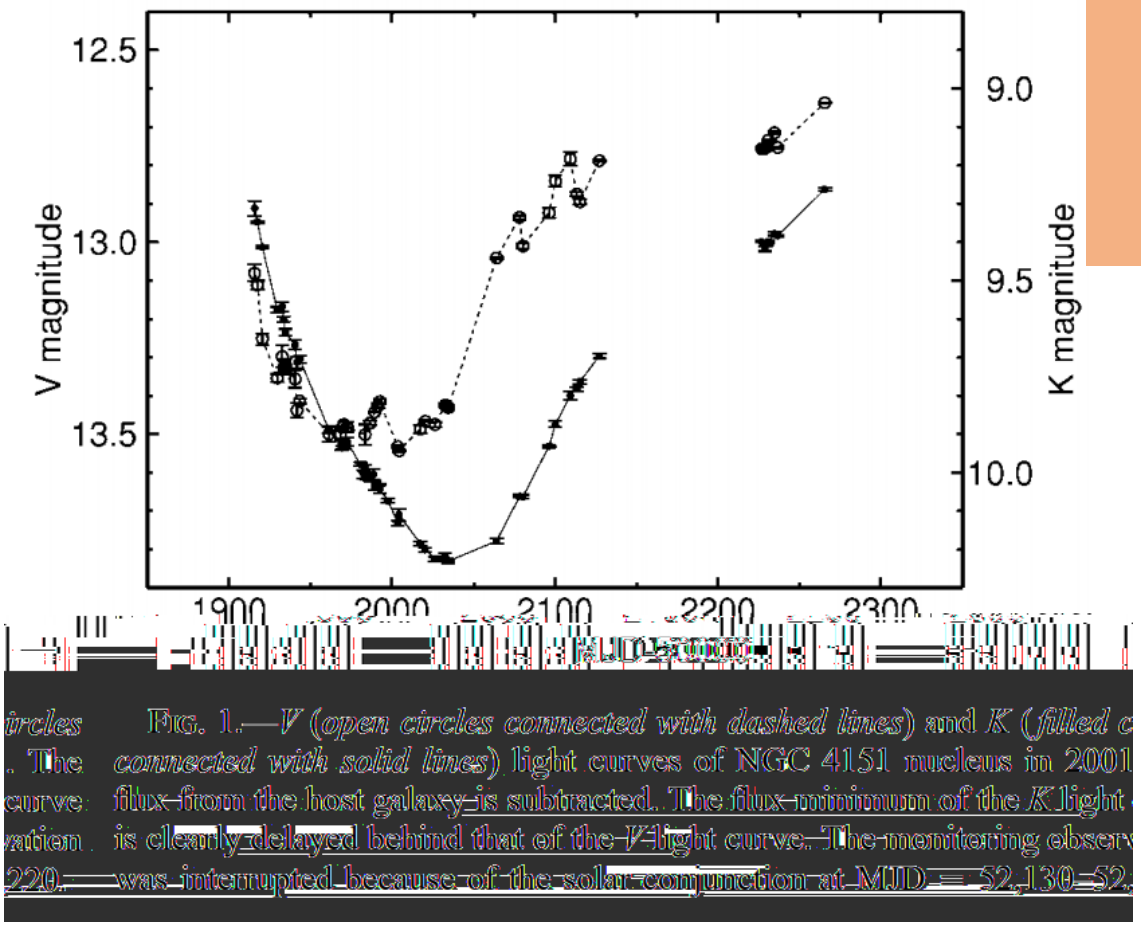


FIG. 1.—*V* (*open circles connected with dashed lines*) and *K* (*filled c*
connected with solid lines) light curves of NGC 4151 nucleus in 2001
flux from the host galaxy is subtracted. The flux minimum of the *K* light
is clearly delayed behind that of the *V* light curve. The monitoring observ
was interrupted because of the solar conjunction at MJD = 52,130–52,

Around 20 AGNs are measured.

Hard to do simultaneous observations in IR and optical bands.

Around 20 AGNs are measured.

AGNs only at low redshifts.

Table 1. Properties of our targets and summary of the results of our KI observations on 15 May 2009 (UT).

Name	z^a corr.	Scale^b (pc mas^{-1})	$E_{B-V}{}^c$ (mag)	$B_p{}^d$ (m)	PA (°)	V^{2e}	$R_{\rm ring}{}^f$ (mas)	$R_{\rm ring}{}^f$ (pc)	$R_{\tau_{\rm K}}{}^g$ (pc)	A_V (mag)
NGC 4151	0.00414	0.086	0.028	85.0	12.3	0.862 ± 0.018	0.45 ± 0.04	0.039 ± 0.003	$\sim 0.044 \pm 0.011$	
NGC 4051	0.00309	0.064	0.013	79.4	41.9	0.861 ± 0.026	0.51 ± 0.05	0.032 ± 0.003	$\sim 0.011 \pm 0.004$	
MRK231	0.0427	0.84	0.010	74.4	44.3	0.923 ± 0.028	0.38 ± 0.07	0.32 ± 0.06		1.3[h]
IRAS 13349+2438	0.109	2.0	0.012	85.0	34.5	0.869 ± 0.016	0.44 ± 0.03	0.88 ± 0.05		0.93[i]

[a] CMB corrected value from NED. [b] $H_0 = 70$ km s^{-1} Mpc^{-1}, $\Omega_{\rm m} = 0.3$, and $\Omega_\Lambda = 0.7$. [c] Galactic reddening from Schlegel et al. (1998). [d] Projected baseline lengths. [e] For objects with multiple measurements, V^2 data shown are at the longest baseline length, except for NGC 4051 where the one with a smaller error is shown. [f] Thin-ring radius (best-fit values if multiple data are available). [g] Mean and standard deviation of the reverberation measurements from 2001 to 2006 by Koshida et al. (2009) for NGC 4151, and from 2001 to 2003 by Suganuma et al. (2006) for NGC 4051. [h] Lacy et al. (1982). [i] Wills et al. (1992).

•

• M_{SMBH}

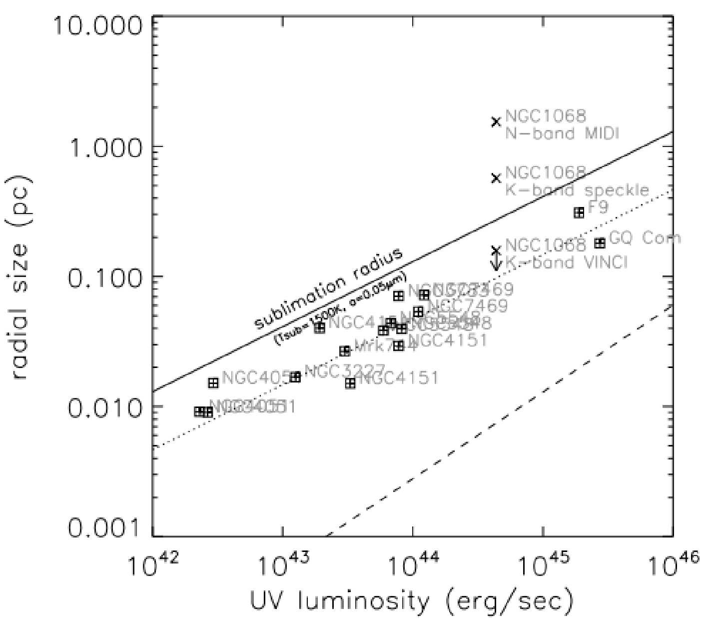
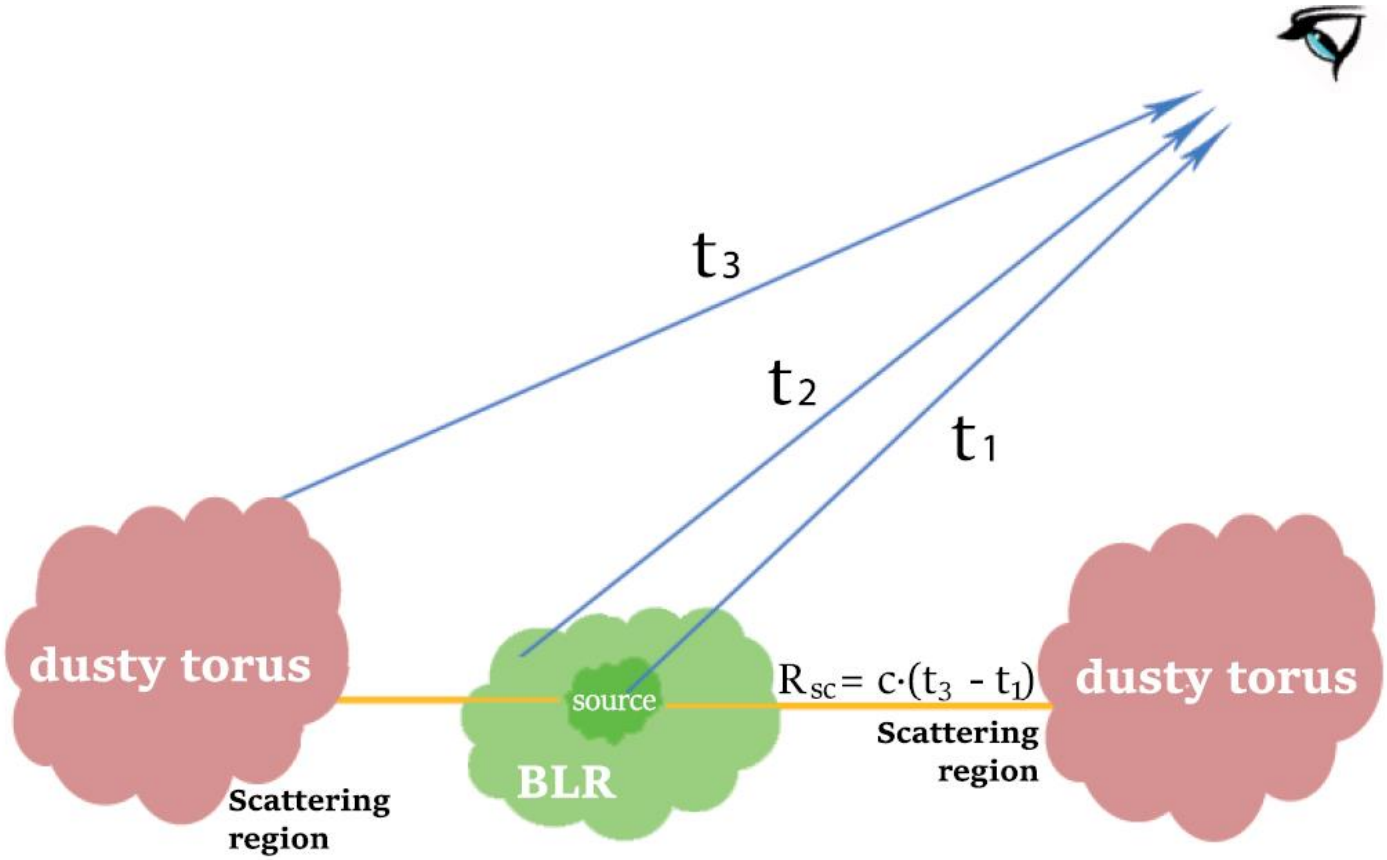
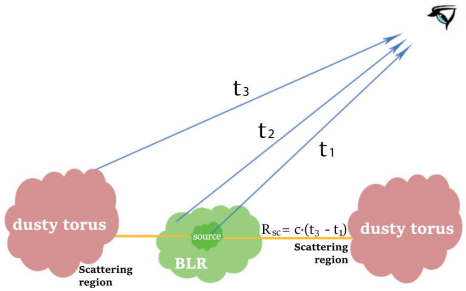


Fig. 4. Dust sublimation radius given by Barvainis (1987; solid line) for T_{sub}=1500K and grain size a=0.05 μm as a function of UV luminosity L_{UV}, as compared with K-band time-lag radii R_{τ_K} for various Type 1 AGNs (Suganuma et al. 2006 and references therein). For the latter, $L_{UV} = 6\ \nu L_\nu(V)$ is assumed, and a fit in $R_{\tau_K} \propto L^{1/2}$ given by Suganuma et al. is shown in dotted line. The dashed line is a rough estimation of K-band emitting radii for an untruncated standard accretion disk. Also plotted are the interferometrically-measured radial sizes approximately perpendicular to the innermost linear radio structure of NGC 1068 ... unobscured) ... The UV luminosity for NGC 1068 here is an estimated value.



$$R_{BLR} = c\Delta\tau_{12} = c \cdot (t_2 - t_1)$$

$$R_{sc} = c\Delta\tau_{13} = c \cdot (t_3 - t_1)$$



$$R_{BLR} = c\Delta\tau_{12} = c \cdot (t_2 - t_1)$$

$$R_{sc} = c\Delta\tau_{13} = c \cdot (t_3 - t_1)$$

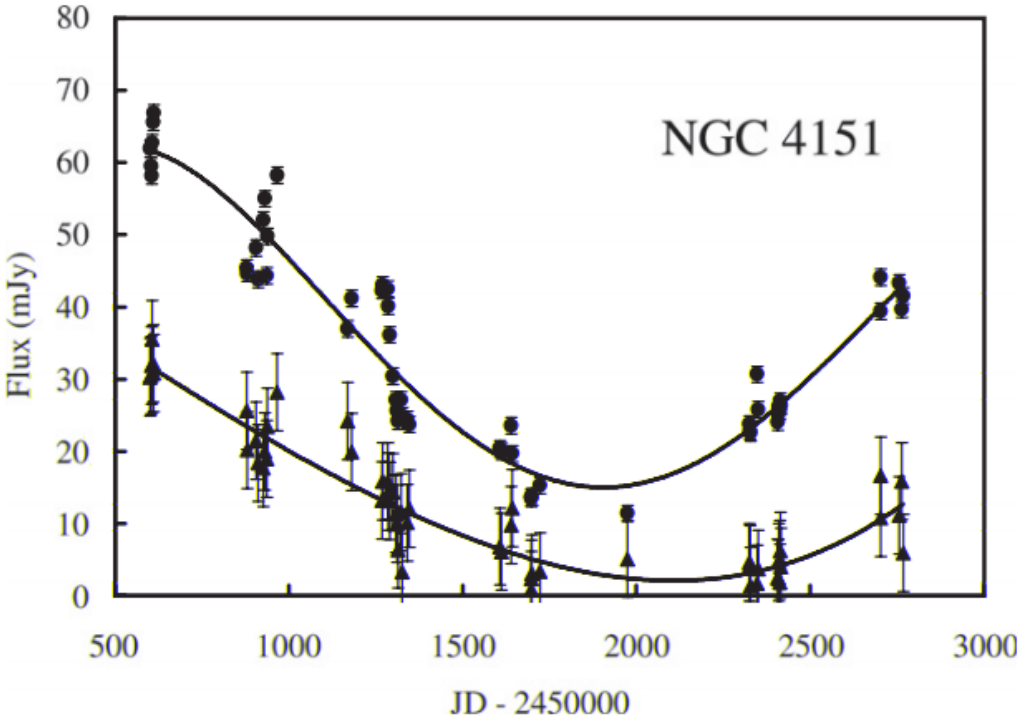
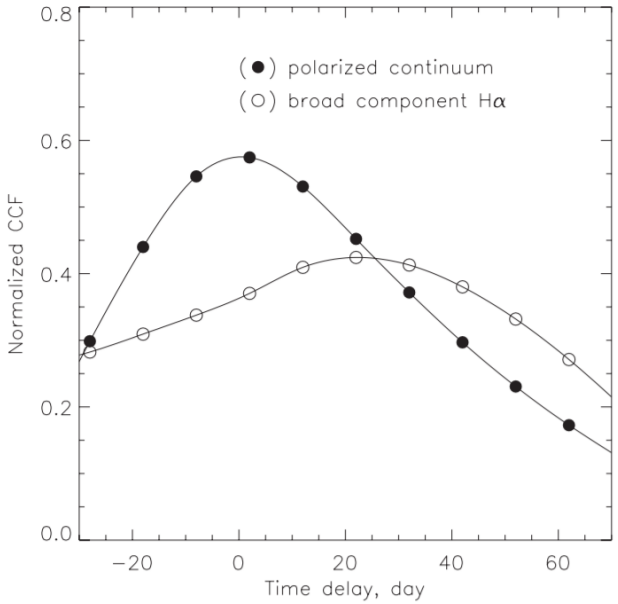


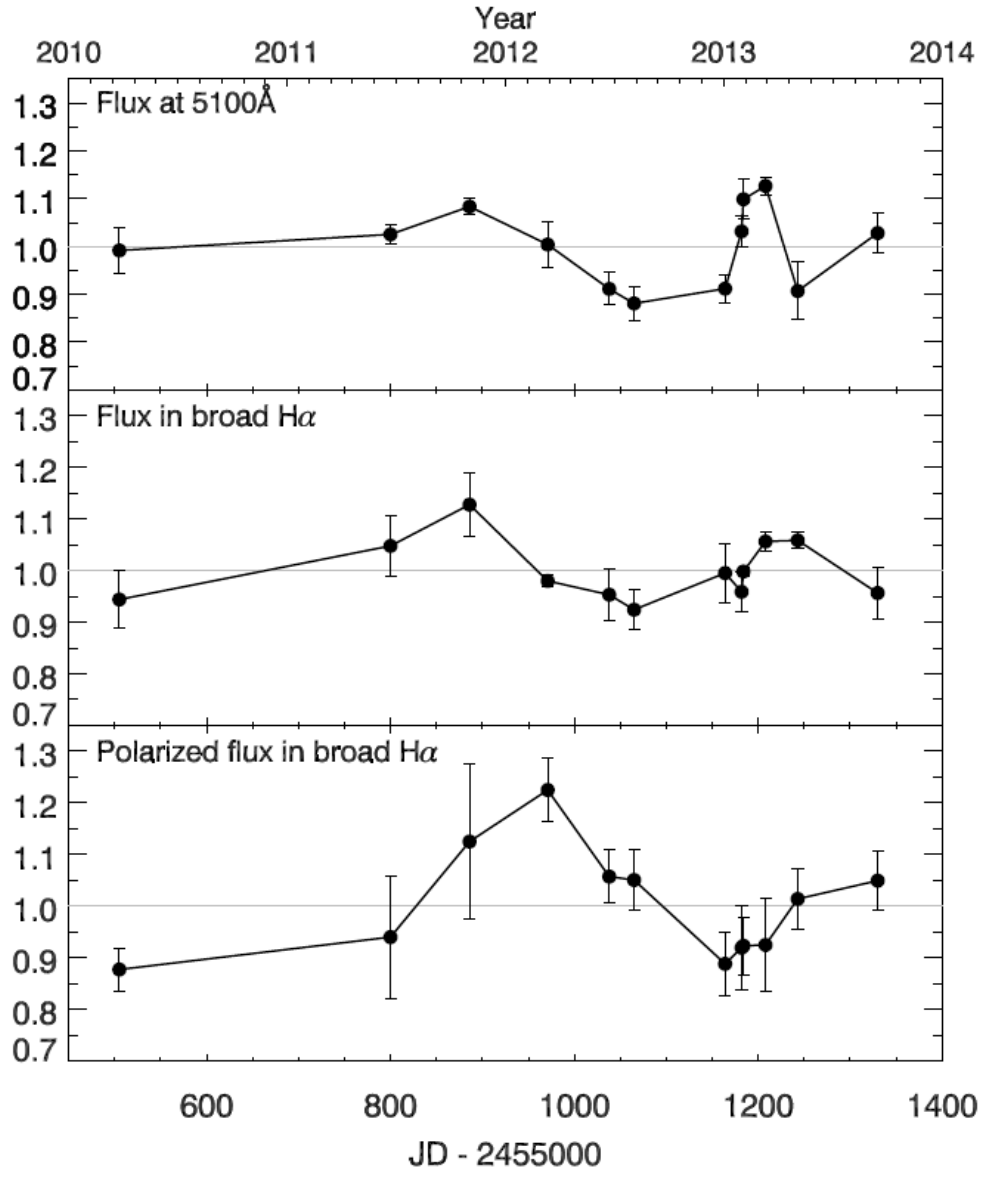
Figure 1. Variations in total *U*-band flux (top curve) and *B*-band polarized flux (lower curve). The polarized flux has been multiplied by a factor of 30 for plotting convenience. The polarization position angles in both wave bands are consistent with each other and remained nearly constant at $92^\circ \pm 1^\circ\!.6$ during the whole observational campaign. The two curves are fourth-order polynomial fits through the data.

Not succeeded.

-
-
-
-
-

α


(●) polarized continuum
(○) broad component Hα
Normalized CCF
Time delay, day

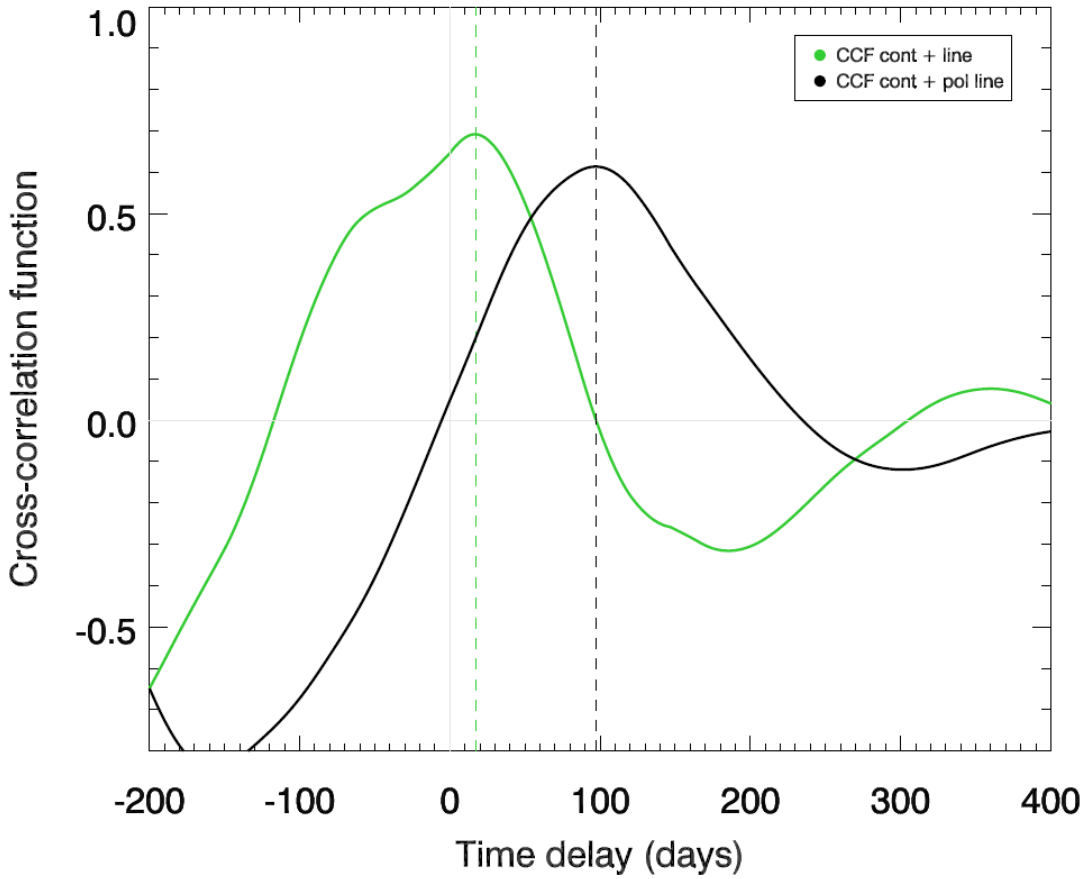

Year
2010
2011
2012
2013
2014
Flux at 5100Å
Flux in broad Hα
Polarized flux in broad Hα
JD - 2455000

$\tau_{13} = 94.7 \pm 6.9$ lt days

$\tau_{JAV} = 99.5 \pm 3.6$ lt days

- 214 ± 59
- ≈ 115

- 13.0 ± 6.4
- 20.3 ± 2
- 20.6 ± 2.0



$$(\tilde{I}_{\text{cont}} \otimes \tilde{I}_{\text{pol-line}})[n] = \frac{1}{N} \sum_{j=0}^{N-1} \{\tilde{I}_{\text{cont}}\}_j \cdot \{\tilde{I}_{\text{pol-line}}\}_{j+n}$$

$$\tau_{13} = 94.7 \pm 6.9 \text{ lt days}$$

$$\tau_{JAV} = 99.5 \pm 3.6 \text{ lt days}$$

- 214 ± 59
- ≈ 115

- 13.0 ± 6.4
- 20.3 ± 2
- 20.6 ± 2.0

The scattering radius of the torus indicates the radius of sublimation, that may differ from the region of the IR maximum dust temperature.