Interpretation of IR variability of AGNs in the hollow, bi-conical, dust-outflow model

Victor Oknyansky [1,2], Martin Gaskell [3]

(1) University of Haifa , Israel

(2) SAI MSU , Moscow , Russia

(3) University of California, Santa Cruz, USA

Abstract

We show that, contrary to simple predictions, **most AGNs show at best only a small increase of lags in the *J*, *H*, *K*, and *L* bands with increasing wavelength.** We suggest that a possible cause of this near simultaneity of the variability from the near-IR to the mid-IR is that the hot dust is in a hollow bi-conical outflow of which we only see the near side. In the proposed model sublimation or recreation of dust in some cloud along our line of sight in the hollow cone could be a factor in explaining the changing look phenomenon of an AGN. The relative wavelength independence of IR lags simplifies the use of IR lags for estimating cosmological parameters.

AGNs with the relative wavelength independence of IR lags:

NGC 4151, NGC 3783, NGC 5548, NGC 7469 (see Fig 1-6)

NGC 6418 (Vazquez et al.2015)

Fairall 9 (Clavel et al.1989)

WPVS48 (Pozo Nuñez et al. 2014)

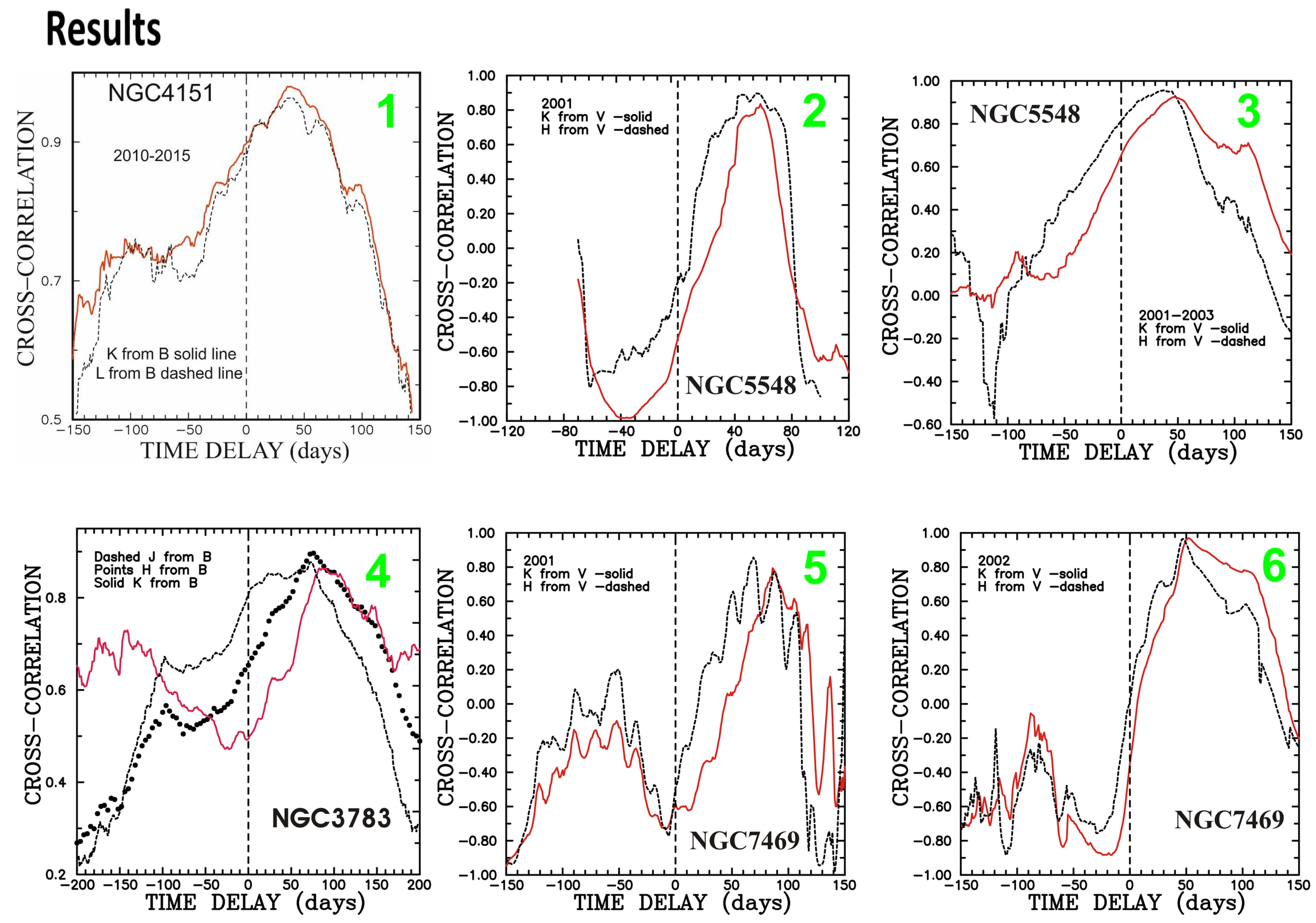
PGC50427 (Pozo Nuñez et al. 2015)

MCG-6-30-15 (Lira et al. 2015)

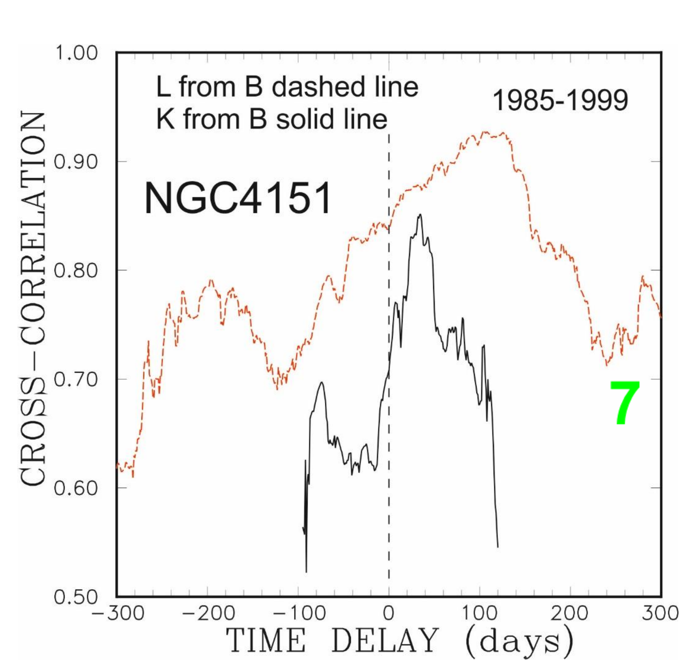
AGNs with different IR lags

NGC 4151 at some epochs (see Oknyansky et al. 1999, 2008, Fig 7).
GQ Comae (see Sitko et al. 1993; Oknyanskij 1999, not shown)

Results

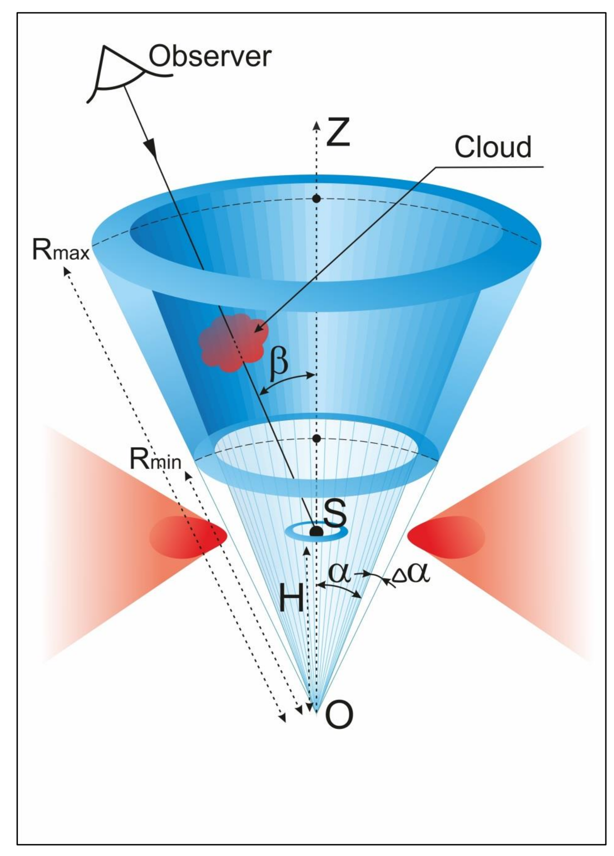


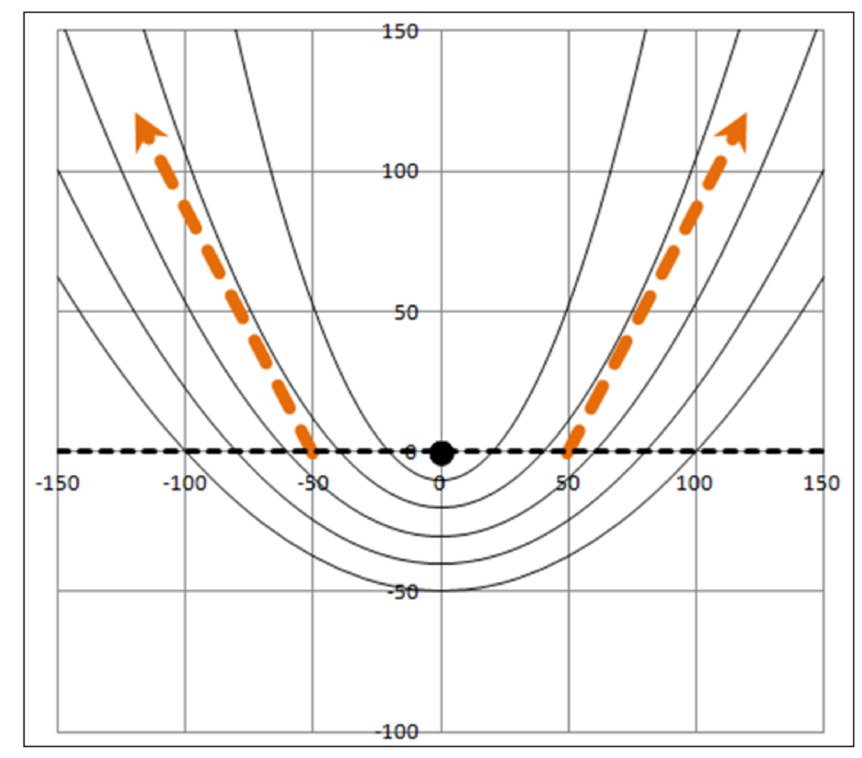
Cross-correlation functions for various IR bands versus the optical (see individual panels). The method for calculating the cross-correlation functions is as given by Oknyanskij et al. (2014, 2022). Data sources are as follows: NGC 4151 (Oknyansky et al. 2019), NGC 5548 (Suganuma et al. 2006), NGC 3783 (Lira et al. 2011), NGC 7469 (Suganuma et al. 2006).



Cross-correlation functions for *L* (dashed line) and *K* (solid line) from *B* variations for NGC4151 for 1985-1999. We suspect that observed difference in the lags can be found only during periods of significant increase in luminosity of the central source, when dust sublimation occurs, and the lag value increases (see Oknyanskij et al.1999).

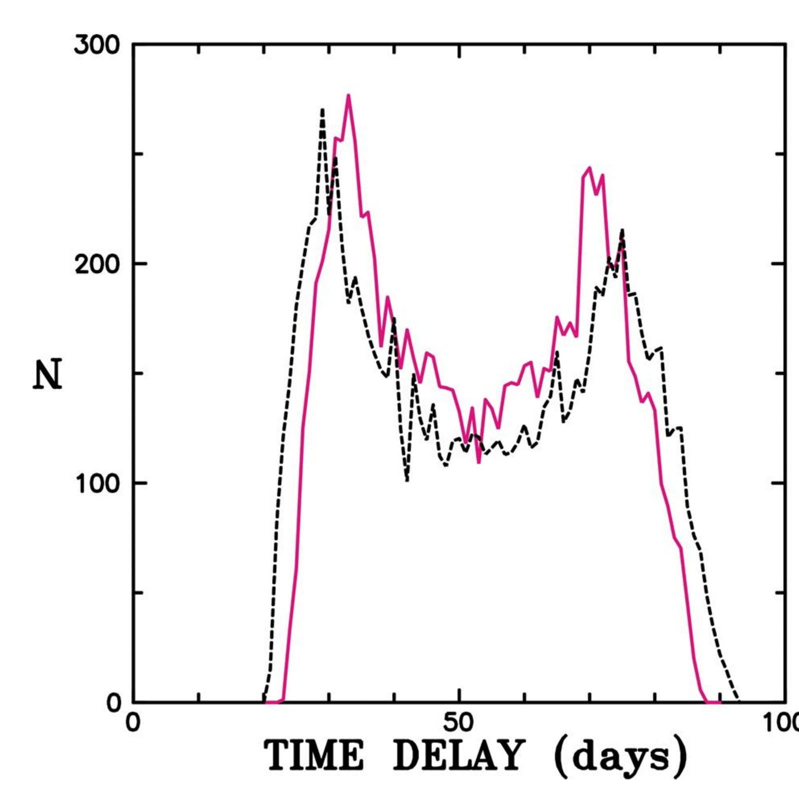
Proposed model





Above. Left panel: Geometry of the near side of the proposed hollow bi-conical dust distribution. Sublimation or recreation of dust in some cloud on the line of sight in the hollow can explain CL events. Right panel: iso-delay contours for light echoes viewed close to the rotation axis. Notice that the outflowing shells (dashed brown arrows) are approximately parallel to iso-delay contours.

Below. Monte Carlo simulations (using 10,000 clouds) of response functions for thin conical shells. H = 90 light days, β = 20°, α = 30°, Δα = 5°, F_{uv} $1/R^2$, axial anisotropy for UV radiation given by F_{uv} $(\cos(\gamma)(1 + 2\cos(\gamma))/3)^{1/2}$. Solid red line: R_{min} = 120 ld, R_{max} = 140 ld, dashed blue line: R_{min} = 140 ld, R_{max} = 160 ld. N is the number of clouds responding per day.



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