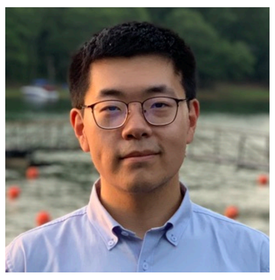

An X-ray study on a sample of AGNs with [OIII] measured inclination

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Abstract

In modeling the X-ray spectra of active galactic nuclei (AGNs), the inclination angle is a parameter that can play an important role, but has never been studied in detail. We present a broadband X-ray spectral analysis of the joint NuSTAR and XMM-Newton archival data of 14 sources with [OIII] measured inclina-tions. By freezing the inclination angles at the [OIII] measured values, the spectra are well fitted and the geometrical properties of the obscuring structure of the AGNs are better constrained than when the inclination angles are left free to vary. We also check if one could freeze the inclinations at some specific angles (e.g., 60° and 87°) for better constraints on other parameters: **we find that one should always let the inclination angle free to vary or use the ones measured from [OIII]**. A correlation between the Eddington ratio and the covering factor of the obscuring torus is also found.

Result 1: Fixing the Inclination Angle at [OIII] measured values

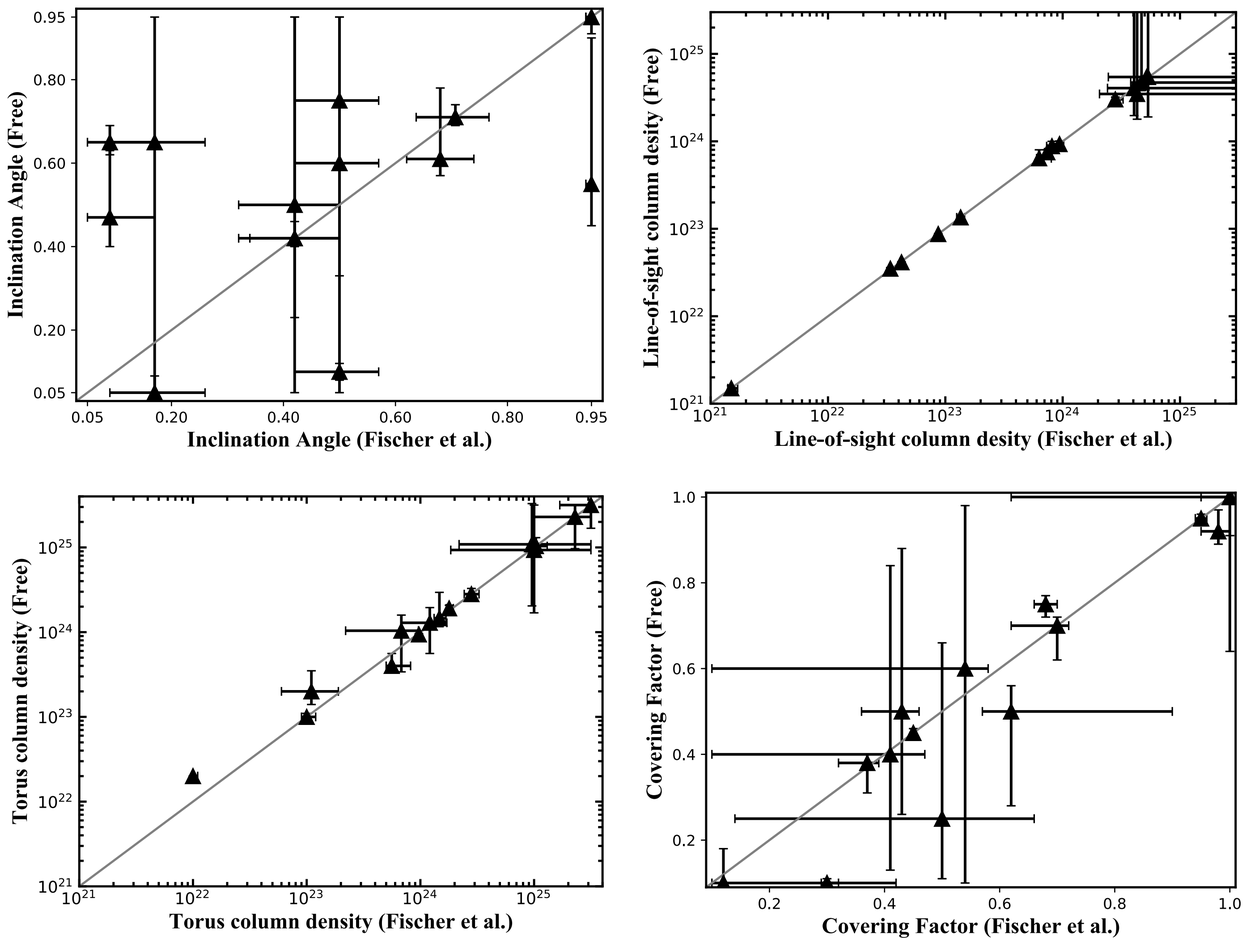

Fig. 1. The inclination angle measured in optical by [OIII], even can be different from that measured in X-ray, can be used to fit the AGNs X-ray spectra, which will provide better constraints on the other parameters without leading to incorrect fits results.

Result 3: Torus Covering Factor Dependencies

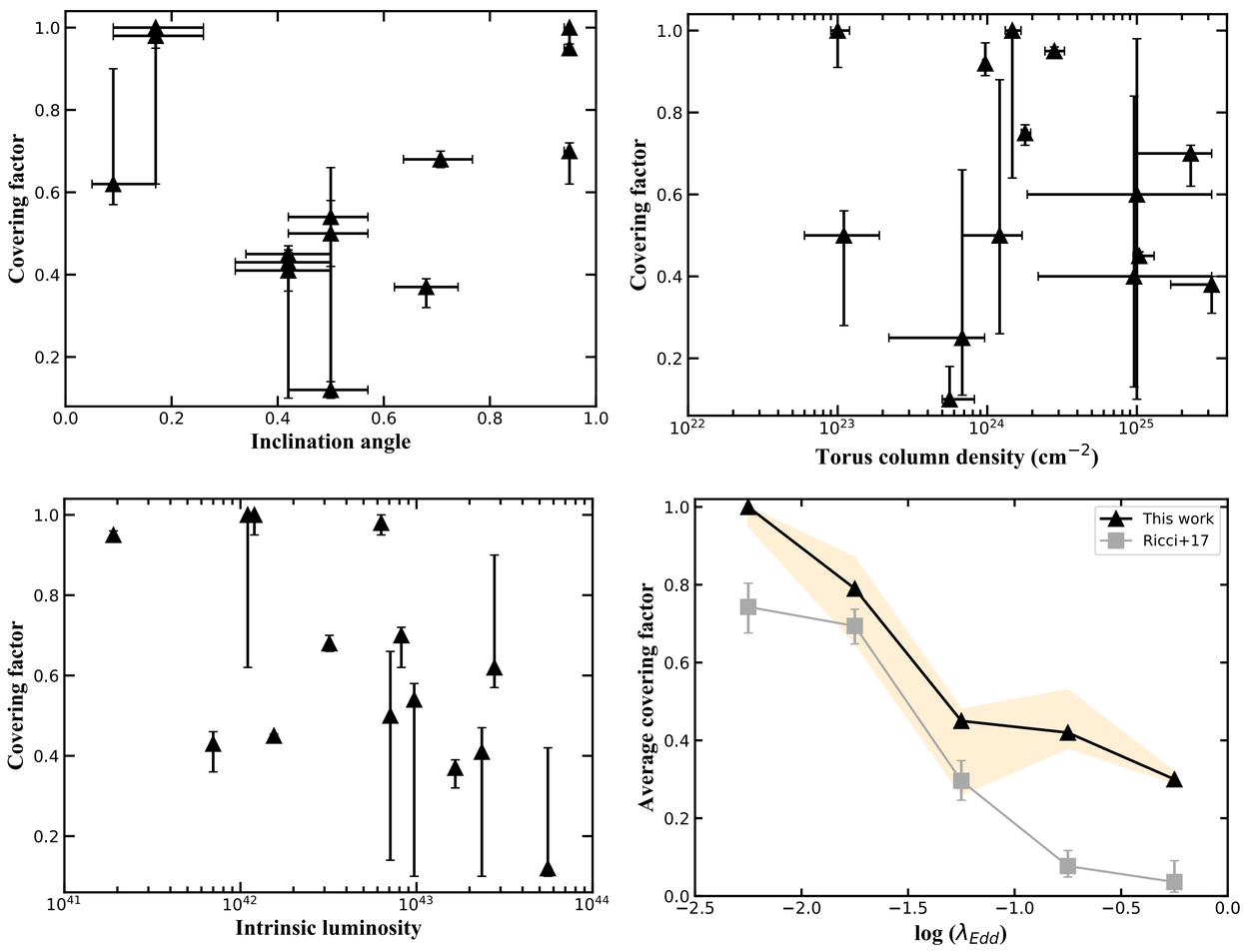

Fig. 3. The covering factor of the torus shows no dependence on the inclination angle, torus column density and intrinsic luminosity, but strongly depends on the Eddington ratio, which can be explained assuming that the distribution of the circumnuclear materials around the SMBH is mainly regulated by the radiative feedback (Ricci et al. 2017).

Background

The intrinsic X-ray emission produced by the central engine of the AGN is reprocessed by the obscuring torus: studying this reprocessed X-ray emission can then provide accurate information about the structure and physics of the torus. In recent years, several tori models based on Monte Carlo simulation have been developed to characterize the X-ray spectra of AGNs, (e.g., MYTorus, Murphy & Yaqoob 2009; borus02, Balokovic et al. 2018). Given the intrinsic complexity of these models and the multiple free parameters involved, applying them in full capability is still difficult even with high-quality X-ray spectra: in particular, the inclination angle of the AGN with respect to the observer is hard to constrain. Thus it is sometimes frozen in the spectral analysis process, although the validity of this method has not been studied in a systematic way. Fischer et al. (2013) successfully measured the inclinations of the NLRs and thus of the torus, with respect to our 'line-of-sight' in 17 AGNs by fitting with a biconical outflow model NLR kinematics resolved by the Hubble Space Telescope (HST) [OIII] imaging.

Result 2: Fixing the Inclination Angle at 60° and 87°

Paramter	Free to vary	[OIII]	87°	60°
$N_{H,l.o.s}$	18%	17%	10%	20%
$N_{H,tor}$	41%	37%	20%	39%
$c_{f,tor}$	0.14	0.10	0.12	0.11
χ^2_ν	1.06	1.06	1.11	1.07

Table 1. Uncertainties on different parameters using different inclination angles.

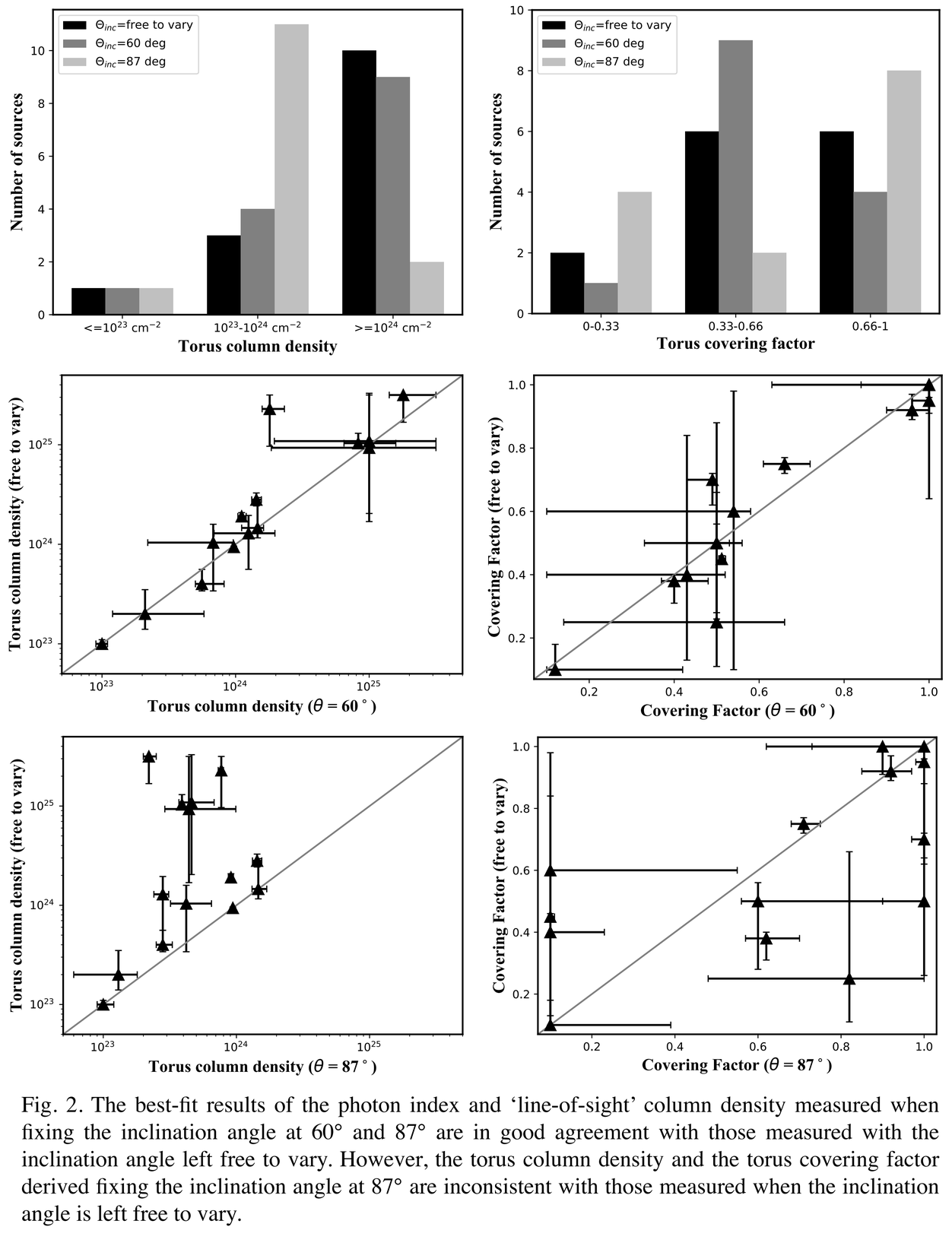

Fig. 2. The best-fit results of the photon index and 'line-of-sight' column density measured when fixing the inclination angle at 60° and 87° are in good agreement with those measured with the inclination angle left free to vary. However, the torus column density and the torus covering factor derived fixing the inclination angle at 87° are inconsistent with those measured when the inclination angle is left free to vary.

Reference:

Balokovic, M., Brightman, M., et al. 2018, APJ, 854, 42
Fischer, T. C., Crenshaw, D. M., et al. 2013, APJS, 209, 1
Murphy, K. D. & Yaqoob, T. 2009, MNRAS, 397, 1549
Ricci, C. Trakhtenbrot, B. ,et al., 2017, Nature, 549, 488