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Measuring Black Hole Spins in Radio-quiet type I AGN

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Abstract

The relativistically broadened iron Kα line emitted from the innermost accretion regions around a supermassive black hole (SMBH) contains information about the black hole spin described by the Kerr metric in general relativity. The innermost regions in radio-quiet type I active galactic nuclei (AGN) are not heavily obscured by the dusty regions. In this work, a Markov chain Monte Carlo (MCMC) method is employed to fit a relativistic ray-tracing reflection model to X-ray observations of a sample of radio-quiet type I AGN. The parameters of the relativistic reflection model, namely the black hole spin, inclination angle, iron abundance, and reflection fraction, are determined by our MCMC-based method. A spin survey of a larger sample will help us better understand the implications of spins for AGN feedback.

BACKGROUND

The spins of supermassive black holes can be determined from the relativistically broadened Kα iron line and Compton hump reflected (see Fig. 1) emitted from the innermost accretion regions (see e.g., Reynolds & Nowak 2003; Brenneman & Reynolds 2006; Brenneman 2013; Reynolds 2019). The dusty regions do not typically obstruct the innermost regions of radio-quiet type I AGN, making them potentially a perfect sample for a black hole spin study.

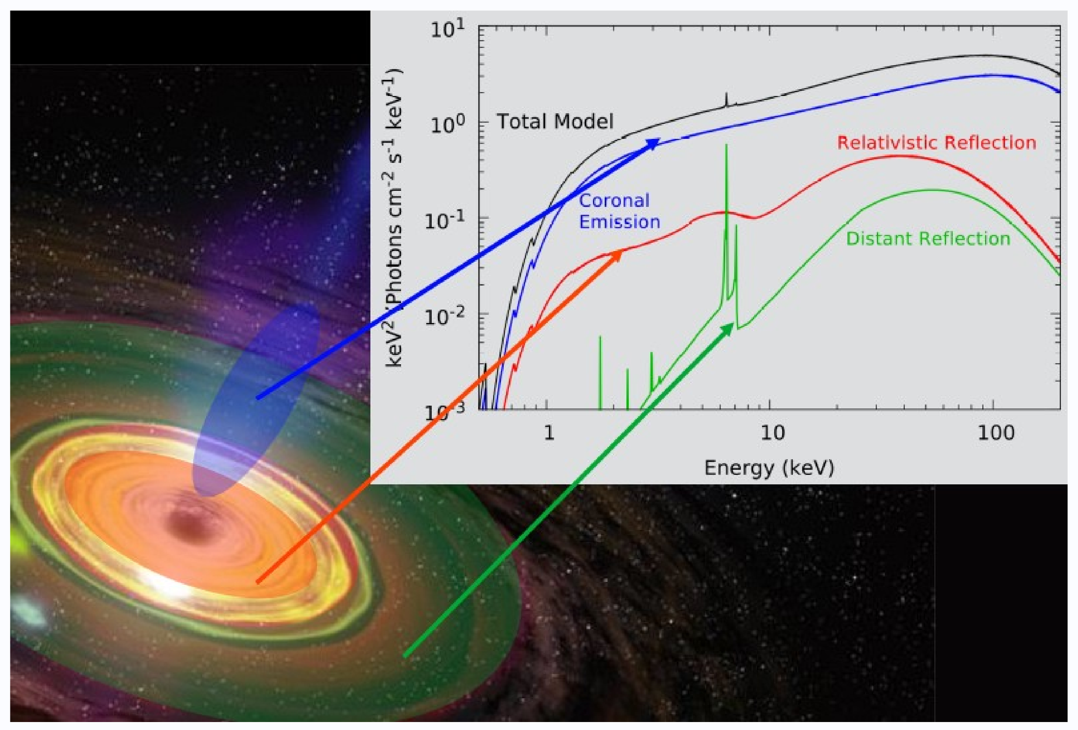

FIG 1. Relativistically broadened Fe Kα line and Compton continuum of a type I AGN (Credit Graphic by NASA/Dana Berry and Spectra by Javier García).

REFLECTION MODELING OF ACCRETION DISKS

We fitted the relativistic reflection model *relxill* and non-relativistic distant reflection model *xillver* to X-ray observations collected by XMM-Newton and NuSTAR of a sample of radio-quiet type I AGN (NGC3783 and MCG-5-23-16 shown in Fig. 2) using (models fully described in Garca et al. 2014). The Bayesian MCMC-based Python package pyBLoCXS (van Dyk et al. 2001; Protassov et al. 2002)) was used to produce the posterior probability distributions of the best-fitting parameters of the reflection models (see Fig. 3).

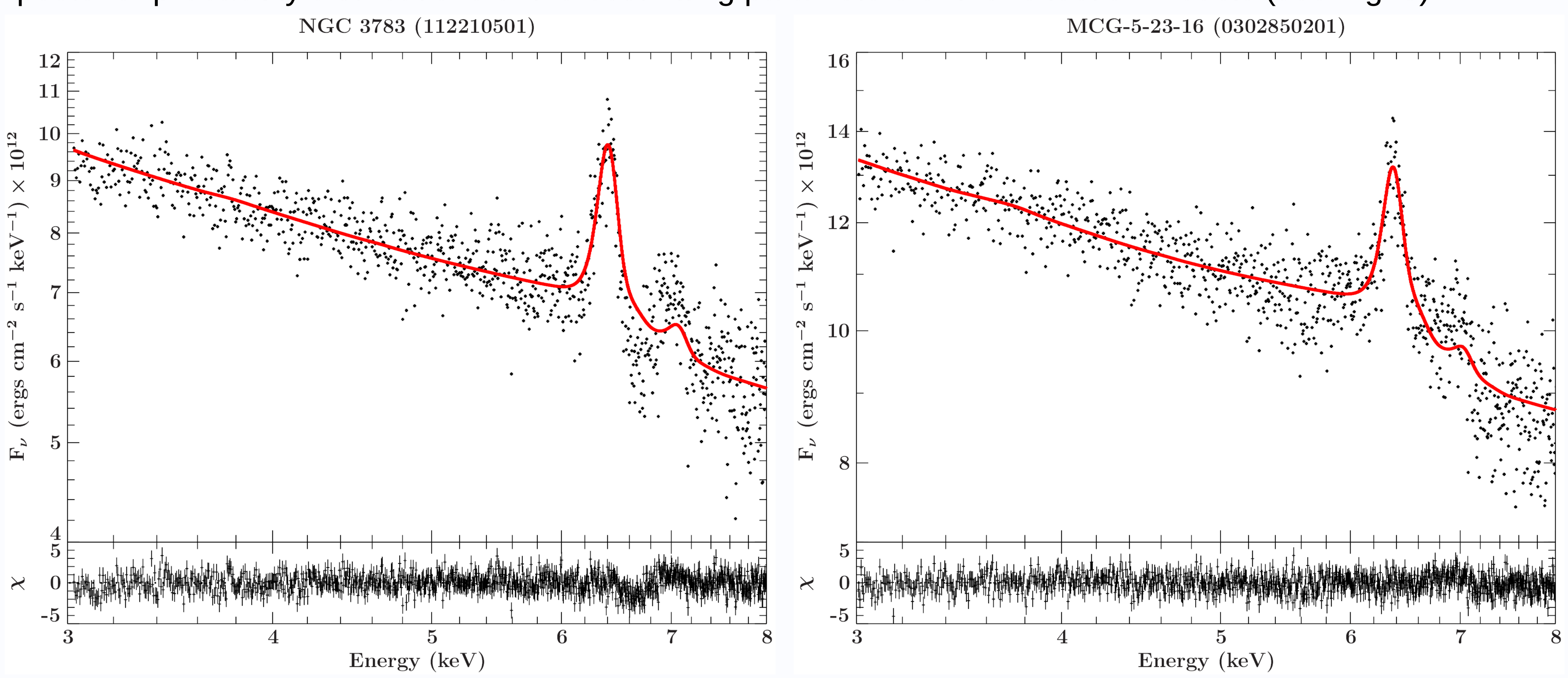

FIG 2. XMM-Newton X-ray observations of NGC3783 (left) and MCG-5-23-16 (right) fitted with the relativistic reflection model (relxil) and non-relativistic reflection model (xillver), a=0.92 and 0.998, respectively, with probability distributions (NGC3783) in Fig. 3.

BAYESIAN MCMC FITTING RESULTS

Our Bayesian MCMC-based method constrained the best-fit parameters of the *relxill* reflection model (Fig. 3).

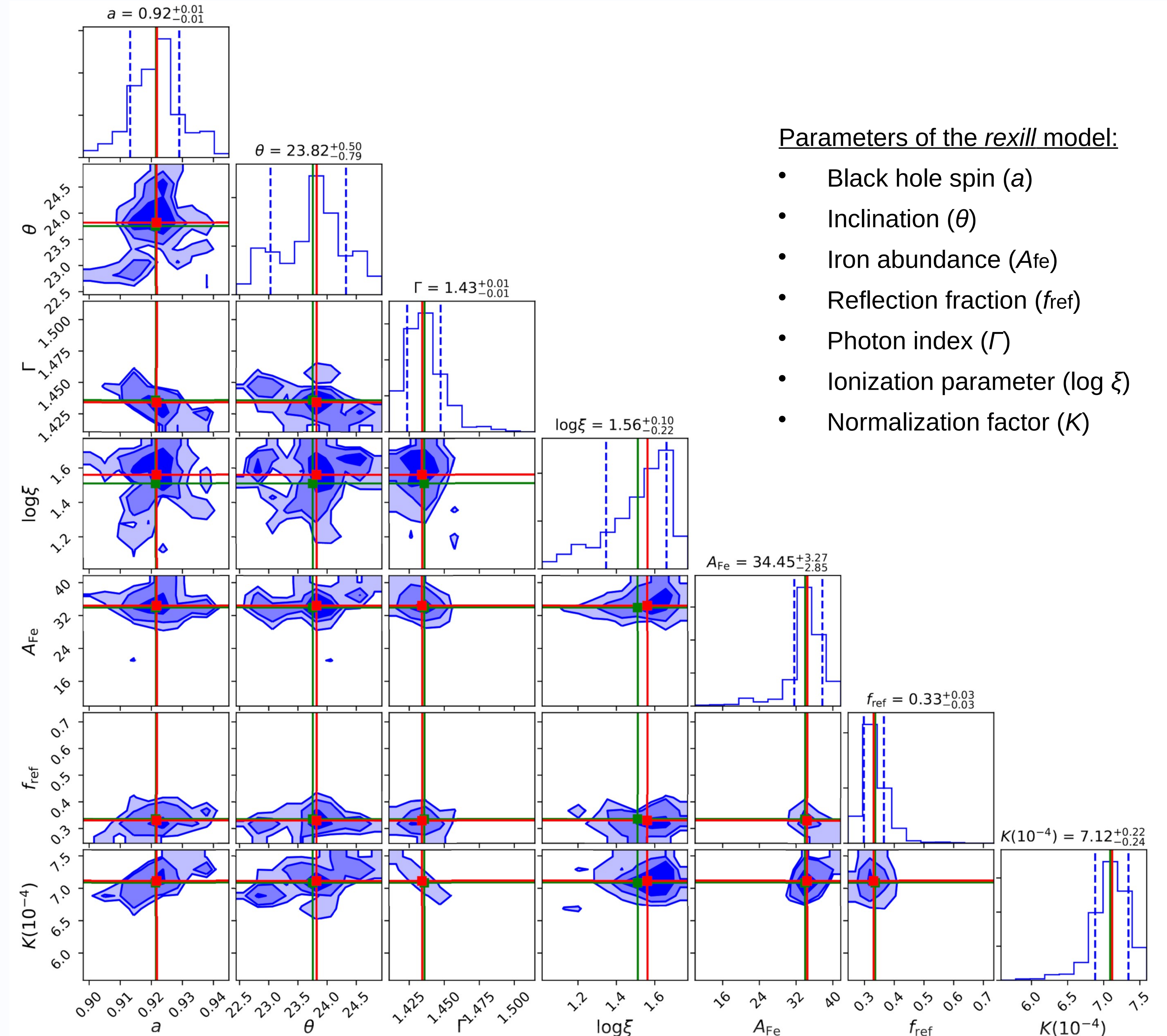

FIG 3. Posterior probability distributions of the parameters of the rexill reflection model for NGC3783: spin (a), inclination angle (θ), powerlaw index (Γ), ionization parameter (log ξ), iron abundance (A_{Fe}), reflection fraction (f_{ref}), and normalization (K).

CONCLUSION

Our study suggests that the iron abundances, which are usually assumed to be the solar composition, could affect the resolved black hole spins (also found by Reynolds et al. 2012). The inclination angle, and other parameters, should be carefully constrained to determine better black hole spins. Measuring black hole spins of a larger sample of radio-quiet type I AGN will shed light on the mechanism behind nearly-relativistic ultra-fast outflows seen in AGN and how they impact their host galaxies.

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