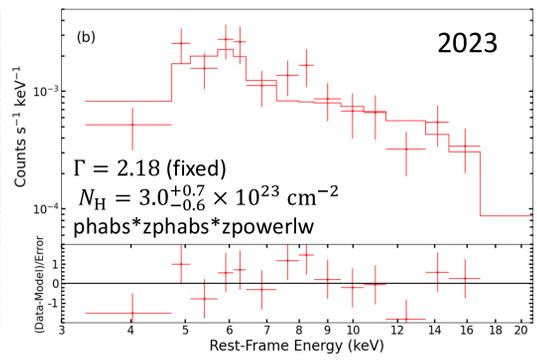
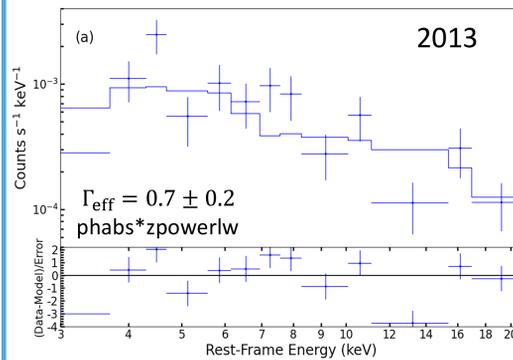
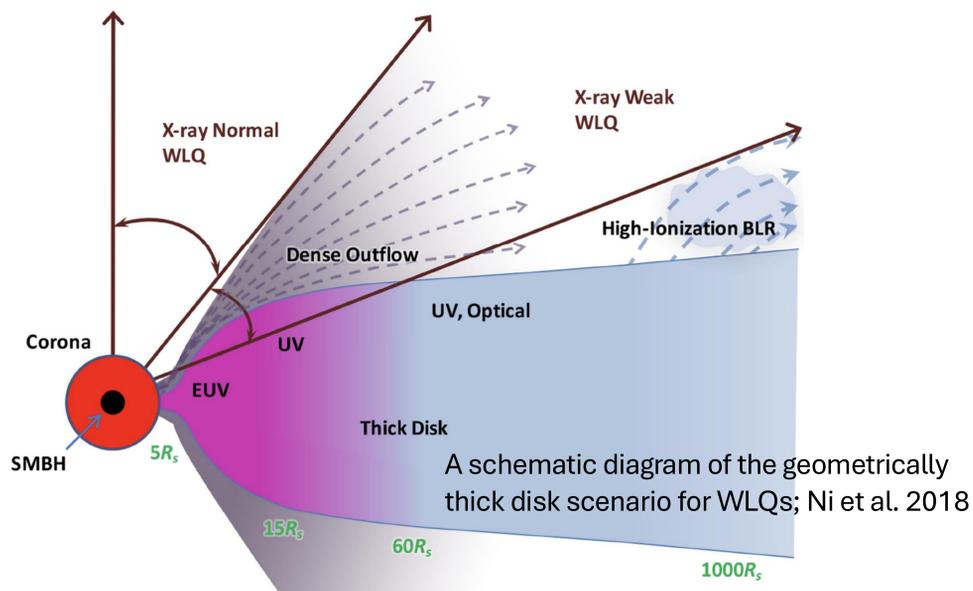


The Remarkable X-Ray Spectra and Variability of the Ultraluminous Weak-line Quasar SDSS J1521+5202

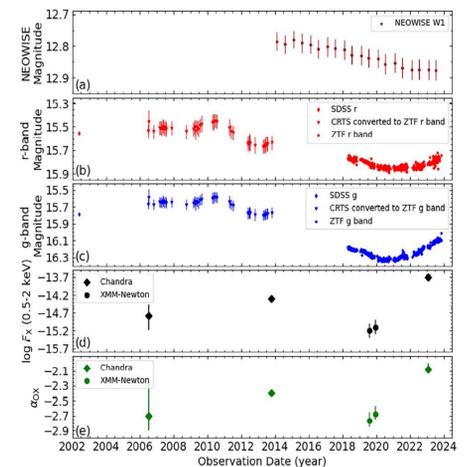
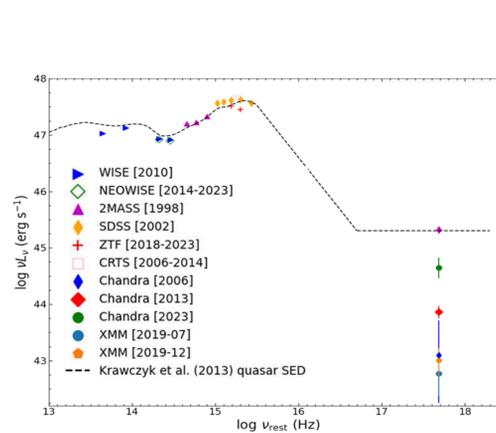
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Introduction

- **Weak line quasars (WLQs)** are blue, luminous type1 quasars with remarkably weak and highly blueshifted high-ionization emission lines.
- About half of the WLQs are **X-ray weak**.
- The above phenomena can be explained by **the thick disk and its outflow (TDO)** model.



Spectral Energy Distributions and Light Curves



- The IR-optical SED of SDSS J1521+5202 is broadly consistent with those of **typical luminous quasars**.
- The long-term IR/optical variability amplitudes of SDSS J1521+5202 are mild.
- However, this quasar showed **remarkable X-ray weakness** in most epochs and **X-ray variability**.

X-ray Observations

- SDSS J152156.48+520238.4 (SDSS J1521+5202) is an X-ray weak WLQ at $z = 2.24$ with $M_i = -30.2$. **It was observed by Chandra and XMM-Newton.**

	ObsID	Obs Date	Exp (ks)	Net cts	Bkg cts
Chandra	6808	2006-07-16	4.1	2.8	0.3
	15334	2013-10-22	37.2	88.4	3.6
	27364	2023-02-02	29.7	111.0	3.1
XMM	0840440101	2019-07-26	42.1 (pn)	22.8 (pn)	34.2 (pn)
	0840440201	2019-12-16	46.6 (pn)	22.6 (pn)	59.4 (pn)

X-ray Spectral Analyses

- SDSS J1521+5202 shows remarkable X-ray weakness and **small Γ_{eff} values** (-0.1–1.4) in all X-ray observations spanning 17 years, indicating consistently strong X-ray absorption.
- The 2023 Chandra spectrum can be acceptably described by a **heavily absorbed power-law**, but this model **does not** fit the 2013 spectrum well with a **high rejection probability**.
- We also tried various other models, including partial covering absorption, double-absorber, Compton-reflection from obscuring tori (*borus*), and ionized reflection (*relxill*). **None of the models return acceptable fit to the 2013 spectrum.**

Discussion and Summary

- The overall X-ray and multiwavelength properties of SDSS J1521+5202 are **qualitatively consistent with expectations for the TDO model**.
- The large X-ray variations could be driven by changes in the column density and/or the covering factor of the TDO.
- The fact that a Compton-reflection model does not fit the 2013 Chandra spectrum well indicates that **the thick disk itself is probably not lying along our LOS**. Rather, at least in the case of SDSS J1521+5202, the **outflow from the thick disk** is probably what lies along LOS.



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