1. INTRODUCTION

HE 0450–2958 is a bright quasar (z = 0.285) located ~1.5″ from an ultraluminous infrared galaxy (ULIRG) and was revealed by the Hubble Space Telescope (Boyce et al. 1996; Canalizo & Stockton 2001). Recently, there have been controversies concerning the nature of HE 0450–2958 (Magain et al. 2005; Merritt et al. 2006; Haehnelt et al. 2006; Hoffman & Loeb 2006). HE 0450–2958 resides in an elliptical galaxy. Assuming that the quasar is accreting at half the Eddington limit with a radiative efficiency of 10%, Magain et al. (2005) inferred the mass of the central supermassive black hole (SMBH) to be $8 \times 10^8 M_\odot$ from the quasar absolute magnitude $M_V = -25.8$. They argued that the host-galaxy luminosity is at least 6 times fainter than that predicted from the relation between the SMBH mass and the host-galaxy spheroid luminosity (McLure & Dunlop 2002). They thus concluded that the quasar’s host galaxy is dark, or that the quasar is “naked.” This suggests possible evidence for the ejection model (Haehnelt et al. 2006; Hoffman & Loeb 2006) can be ruled out, since the narrow emission line gas remains bound to the SMBH, as shown by the quasar’s optical spectra.

The controversies lie in the host’s nature and the SMBH mass of the quasar. X-ray observations, as a powerful probe of SMBH activities (Mushotzky et al. 1993), may provide independent clues to understand the nature of the source. Here we present an XMM-Newton observation of the X-ray counterpart of HE 0450–2958. We find that it is a high-state Seyfert 1 galaxy, i.e., accreting above the Eddington limit. Throughout this paper we use the cosmological parameters $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_m = 0.3$, and $\Omega_\Lambda = 0.7$.

2. DATA REDUCTION

HE 0450–2958 was observed by XMM-Newton on 2003 September 9 during orbit 687 (principal investigator: N. Anabuki). The observational details of the European Photon Imaging Camera (EPIC) onboard XMM-Newton, including the two MOS cameras (Turner et al. 2001) and the pn camera (Strüder et al. 2001), can be seen in Table 1.

The cookbook for the XMM-Newton data analysis software SAS in the XMM-Newton Data Center at the Max-Planck-Institut für extraterrestrische Physik is referred to for the data reduction. The EPIC data are screened with the SAS version 6.0 software (Gabriel et al. 2004), and the corresponding calibration files are available. The X-ray events corresponding to patterns 0–4 (single- and double-pixel events) for the pn data and patterns 0–12 for the MOS data are selected. The EPIC data are used in the 0.3–10 keV range, and hot or bad pixels are removed. We extract the source spectra from a circle within 3″ (760 pixels) of the detected source position, with the background being taken from a circular source-free region with the same size, avoiding the CCD chip gaps. The presence of background flaring in the observation has been checked and removed using a Good Time Interval file, leaving 13.1 ks for the pn and 15.2 ks for the MOS. We find no pile-ups in the EPIC data after checking with the SAS task epatplot. The response files are generated with the SAS tools rmfgen and arfgen. Spectral files are binned to at least 20 counts bin$^{-1}$ to apply the χ$^2$ statistics. The spectral fit is based on the XSPEC version 12.3.0 package (Arnaud 1996). Errors are quoted at the 90% confidence level ($\Delta \chi^2 = 2.71$).

The X-ray source is located at $\alpha = 04^h52^m30.2^s$, $\delta = -29^\circ53'34.6''$ (J2000.0). Note that EPIC has a spatial resolution of ~10″ or worse (Ghizzardi et al. 2001); however, the quasar is ~1.5″ apart from the ULIRG. Thus, the HE 0450–2958 system cannot be resolved spatially by EPIC. All the fits include the
absorption due to the line-of-sight Galactic column of \( N_H = 1.68 \times 10^{20} \) cm\(^{-2}\) (Dickey & Lockman 1990), and fitting parameters are given in the rest frame.

3. RESULTS

3.1. Temporal Analysis

3.1.1. Excess Variance

We extract the 2–10 keV EPIC pn light curve with a time bin of 256 s, the same as was adopted by O’Neill et al. (2005). The count rates show evident variations on an approximately kilosecond timescale (Fig. 1). To quantify the X-ray variability of HE 0450–2958, we invoke the X-ray excess variance, denoted as \( \sigma_{\text{rms}}^2 \) (Nandra et al. 1997; Turner et al. 1999),

\[
\sigma_{\text{rms}}^2 = \frac{1}{N\mu^2} \sum_{i=1}^{N} \left[ (X_i - \mu)^2 - \sigma_i^2 \right],
\]

where \( X_i \) is the count rates for the \( N \) points in the light curve, with errors \( \sigma_i \), and \( \mu \) is the arithmetic mean of \( X_i \). The errors of \( \sigma_{\text{rms}}^2 \), which depend on the measurement uncertainties and the stochastic nature of the source, can be expressed as (O’Neill et al. 2005)

\[
\Delta_{\text{tot}}(\sigma_{\text{rms}}^2) = \sqrt{\left( \frac{\sigma_{\text{frac}}^2 \sigma_{\text{rms}}^2}{\sqrt{N_{\text{seg}}}} \right)^2 + \Delta_{\text{boot}}(\sigma_{\text{rms}}^2)^2},
\]

where \( N_{\text{seg}} \) is the number of available light-curve segments and \( \sigma_{\text{frac}} \) is a fractional standard deviation: \( \sigma_{\text{frac}} = 0.74 \) for \( \log M_{\text{BH}} > 6.54 \) and \( \sigma_{\text{frac}} = 0.48 \) for \( \log M_{\text{BH}} < 6.54 \). Here \( \Delta_{\text{boot}}(\sigma_{\text{rms}}^2) \) is the bootstrap uncertainty, which comes from the bootstrap simulation accounting for the measurement uncertainties. We find that \( \sigma_{\text{rms}}^2 = 0.0081 \pm 0.0063 \) from the 2–10 keV EPIC pn data. We do not use the EPIC MOS data, since the MOS data have much lower count rates with relatively larger errors.

3.1.2. Time Lag

We calculate the cross-correlation function (CCF) between the light curves of 0.3–2 and 2–10 keV with a time bin of 50 s (Fig. 2). The CCF is obtained using the XRONOS command \texttt{crosscor}, which uses a direct Fourier method to compute the coefficient. Errors are obtained via propagating the errors of the concerned light curves through the cross-correlation formulae. The results show the hard X-ray to be not lagging with respect to the soft X-ray emission.

3.2. Spectral Analysis

3.2.1. Power Law

We use the EPIC data (pn+MOS1+MOS2) for the spectral analysis to improve the photon statistics, allowing tighter constraints on spectral parameters. Initially we use a power law to fit the data above 1 keV with a free intrinsic absorption. A good fit can be obtained (\( \chi^2 \) of 1.06 for 521 degrees of freedom [dof]) with the intrinsic absorption consistent with zero. A substantial

| Instrument Mode | Filter | Time (ks) |
|-----------------|--------|-----------|
| MOS 1............| Full frame | Medium | 15.7 |
| MOS 2............| Full frame | Medium | 15.7 |
| pn..................| Full frame | Medium | 14.0 |

TABLE 1

**INSTRUMENT MODES AND EXPOSURE TIMES**

**Fig. 1.**—The 2–10 keV EPIC pn light curve of HE 0450–2958 with a time bin of 256 s, showing the rapid variability.

**Fig. 2.**—CCF between the light curves of 0.3–2 and 2–10 keV with a time bin of 50 s, showing no time lag between these two X-ray bands.

**Fig. 3.**—EPIC pn (light gray), MOS1 (black), and MOS2 (dark gray) spectra of HE 0450–2958. The data are fitted with a simple power law over 1–10 keV, index \( \Gamma = 2.14 \pm 0.03 \). A soft X-ray excess is clearly seen below 1 keV. [See the electronic edition of the Journal for a color version of this figure.]

We use all the EPIC data (pn+MOS1+MOS2) for the spectral analysis to improve the photon statistics, allowing tighter constraints on spectral parameters. Initially we use a power law to fit the data above 1 keV with a free intrinsic absorption. A good fit can be obtained (\( \chi^2 \) of 1.06 for 521 degrees of freedom [dof]) with the intrinsic absorption consistent with zero. A substantial
soft X-ray excess below 1 keV can be seen in the EPIC pn and MOS data when extrapolating this power law over the full energy range of EPIC (Fig. 3).

We use the models listed in Table 2 to fit a 0.3–10 keV spectrum. The soft X-ray excess is traditionally taken as thermal emission (e.g., Pounds et al. 1995). Model 1 is an absorbed power-law plus blackbody model. This gives an acceptable fit over the full energy range (χ^2/dof = 1.13 for 744 dof, model 1 in Table 2), with a photon index of 2.13±0.03, an intrinsic column density of 2×10^{22} cm^{-2}, a blackbody temperature of 107±10 eV, and a blackbody normalization of 3.09±0.05. There is evidence for a soft excess gap between 0.7 and 0.8 keV in the spectra. We add an absorption edge to model 1. This improves the fit significantly (χ^2/dof = 27.8 for 2 fewer dof, model 2). We find that the edge significance is at a level of >99.9% by applying the F-test. This should be due to the absorption edge of O viii in 739 eV (Reynolds 1997). The second absorption edge due to O vii is not required in this model (χ^2/dof = 1.2 for 2 fewer dof when including the second absorption edge).

3.2.2. Fe Kα Line

We first try to add a Gaussian line with all free parameters. However, this fit does not improve significantly (χ^2/dof = 2.7 for 3 fewer dof). Since the Fe Kα lines in the current data are generally narrow (Nandra 2006), we fix the intrinsic width of the line at 0 eV. This fit is still poor (χ^2/dof = 2.6 for 2 fewer dof), and the line energy cannot be constrained well. We also fix the line energy at 6.40 keV (Fig. 4). This returns an equivalent width of <64 eV. The line significance F^line is at a level of 89% compared to the continuum alone. Generally, the significance should be larger than 90% for the presence of an Fe Kα line. Thus, the line is barely significant.

3.2.3. Soft X-Ray Excess

Recently, it has been suggested that the soft X-ray excess can arise from a relativistically blurred photoionized disk reflection in a large sample of active galactic nuclei (AGNs; Crummy et al. 2006). The relativistic convolution kdblur is included in XSPEC version 12.3.0, and the photoionized disk reflection model REFLION (Ross & Fabian 2005) is also available. We follow Crummy et al. (2006) and fix the outer radius of the accretion disk at 100R_g, where R_g denotes the gravitational radius. This fit (model 4), as shown in Figure 5, is better than the blackbody fit of model 3.

![Fig. 4.—Power-law plus blackbody model fit to the EPIC pn (light gray), MOS1 (black), and MOS2 (dark gray) data (χ^2 of 1.13 for 744 dof, model 3 in Table 2). This model also includes a narrow Gaussian profile and an absorption edge. [See the electronic edition of the Journal for a color version of this figure.]](image1)

![Fig. 5.—Relativistically blurred photoionized disk reflection fit to the EPIC pn (light gray), MOS1 (black), and MOS2 (dark gray) data (model 4 in Table 2). This model also includes a narrow Gaussian profile and an absorption edge. The fit is statistically better than the blackbody fit (χ^2 of 44.1 for 6 fewer dof) and physically plausible. [See the electronic edition of the Journal for a color version of this figure.]](image2)
(Δχ² of 44.1 for 6 fewer dof; see Table 2), with the inner radius of the accretion disk at 1.6^{+0.6}_{-0.2}R_g, the index of the emissivity of the accretion disk at 8.1^{+3.5}_{-1.9}, the iron abundance of the accretion disk at 0.4^{+0.1}_{-0.2}, the photon index for illuminating the power-law spectrum at 2.38^{+0.03}_{-0.02}. Other parameters in this model are listed in Table 2.

We further test the reflection scenario by using the PEXRIV model (Magdziarz & Zdziarski 1995) to fit the 0.3–10 keV spectrum. Although the PEXRIV model does not include the relativistically blurring effect, it can generally represent the reflection from the ionized material. We fix the high-energy cutoff at 200 keV and the reflector at unity (Malizia et al. 2003). This fit (Fig. 6) is worse than that of the blackbody model (Δχ² of 7 for 3 fewer dof) but still acceptable (χ² of 1.15 for 741 dof).

4. DISCUSSION

4.1. Black Hole Mass

We calculate the black hole (BH) mass based on the anticorrelation between the X-ray excess variance σrms and the BH mass (Lu & Yu 2001; Bian & Zhao 2003; Papadakis 2004; O’Neill et al. 2005). Using the correlation derived from equation (3) in O’Neill et al. (2005),

\[ \log M_{\text{BH}} = 5.75 + 1.20 \log \left( \frac{0.144}{\sigma_{\text{rms}}} - 1 \right) \]

we obtain a BH mass of \( 2^{+7}_{-3} \times 10^{7} M_{\odot} \) (Fig. 7).

We plot the spectral energy distribution (SED) for HE 0450–2958 in Figure 8. There is a “big blue bump” (BBB) in the UV band. We fit the BBB with a standard thin accretion disk model (Dörrer et al. 1996) and fit the X-ray data with a power-law plus blackbody model. The accretion disk fit (Fig. 8, dotted line) returns a large BH mass of \( 8 \times 10^{8} M_{\odot} \), with an Eddington ratio of 0.3, an inclination angle cos θ = 0.5, and a BH spin parameter \( a = 0.6 \). This BH mass is much higher than our result. It is possible that the UV and optical data are contaminated by the nearby ULIRG, and thus the SED luminosity is overestimated. A similar case appears in the NLS1 Ton S180; the estimation of BH mass based on the SED from the simultaneous multiple-band observations is also much higher than that from the Hα line width (Turner et al. 2002). In addition, fitting SEDs using a standard thin disk model is not a reliable way to estimate the BH masses in NLS1s, since they may accrete above the Eddington limit, and the standard thin disk model does not work in this case (Kawaguchi et al. 2004). It is worth studying the SED of HE 0450–2958 through a more sophisticated slim disk model (Abramowicz et al. 1988; Wang et al. 1999) in the future.

4.2. Eddington Ratio

The X-ray excess variance is related to the observed X-ray luminosity \( L_X \) and the Eddington ratio \( E = L_{\text{bol}} / L_{\text{Edd}} \) through (Leighly 1999)

\[ \sigma_{\text{rms}}^2 \propto \left( \frac{L_{X}}{\eta E} \right)^{-1-\alpha} \]

where \( L_{\text{bol}} \) is the bolometric luminosity, \( L_{\text{Edd}} \) is the Eddington luminosity, \( \eta \) is the radiation efficiency, and \( \alpha \) is the slope of the power spectrum, assuming \( \alpha = 2 \) (Leighly 1999). The integrated...
2–10 keV flux of HE 0450–2958 is $2.00 \times 10^{-12}$ ergs s$^{-1}$ cm$^{-2}$, corresponding to a luminosity of $5.13 \times 10^{44}$ ergs s$^{-1}$. We find that HE 0450–2958 is located in the NLS1 region in the $\sigma_{\text{kin}}^2/L_{\text{X}}$ plot of Leighly (1999), indicating that HE 0450–2958 has a high Eddington ratio. This supports the hypothesis that HE 0450–2958 is a NLS1 galaxy.

The soft and hard X-rays in HE 0450–2958 may arise from very close regions. As suggested above, a slim disk may be powering HE 0450–2958. The fluctuations of the slim accretion disk might be the origin of the simultaneous X-ray variations (Mineshige et al. 2000; Wang & Netzer 2003). In this case, the slim disk would be suffering the so-called photon bubble instability (Gammie 1998), since the energy densities of the trapped photons and the magnetic field would be larger than those in standard accretion disks. This would lead to the hard X-rays closely following the soft X-ray variations. The zero lag between the soft and hard X-rays in HE 0450–2958 supports this scenario.

The obtained hard photon index of 2.16$^{+0.03}_{-0.01}$ is steeper than the average photon index of 1.8–2.0 in Seyfert 1 galaxies (Nandra & Pounds 1994) and quasars (George et al. 2000; Reeves & Turner 2000). AGNs with steep X-ray indices, as well as strong soft X-ray emission, have been considered as high-state objects (Pounds et al. 1995). According to the anticorrelation between the FWHM(H$\beta$) and the hard X-ray index (Brandt et al. 1997), the FWHM(H$\beta$) of HE 0450–2958 should be narrow, also consistent with a NLS1.

The hard X-ray photon index is related to the Eddington ratio (e.g., Shemmer et al. 2006). We calculate $\epsilon$ from the $\Gamma_{2-10\text{ keV}} = \epsilon$ relation in Wang et al. (2004),

$$\Gamma_{2-10\text{ keV}} = 2.05 + 0.26 \log \epsilon.$$  

We find $\epsilon = 3 \pm 1$ for $\Gamma_{2-10\text{ keV}} = 2.16 \pm 0.03$. This suggests that HE 0450–2958 is accreting above the Eddington limit.

The AGN bolometric luminosity can be estimated from the X-ray luminosity by multiplying by the bolometric correction $f_{\text{bol}}/L_X$. We find the bolometric luminosity to be $9.16 \times 10^{45}$ ergs s$^{-1}$ by assuming $f_{\text{bol}}/L_X = 17.33$. The $f_{\text{bol}}/L_X$ value we use is the range in conversion factors in which the bolometric luminosity accounts for the X-ray luminosity found in Elvis et al. (1994), which is also consistent with recent estimations by Marconi et al. (2004) and Barger et al. (2005). We then estimate a BH mass of $2.15^{+5.12}_{-1.12} \times 10^7 M_\odot$ for $L_{\text{bol}} = 9.16 \times 10^{45}$ ergs s$^{-1}$ and $\epsilon = 3$, which agrees with the BH mass from the X-ray variability.

The weak Fe K$\alpha$ emission might also be due to the high Eddington ratio (Pounds et al. 2003) due to the anticorrelation between the equivalent width of the narrow Fe K$\alpha$ line and the Eddington ratio (Zhou & Wang 2005).

4.3. On the Origin of Soft X-Ray Excess

The origin of the soft X-ray excess is still under debate. The traditional view is that the soft X-ray excess is the high-energy tail of a BBB, which is the thermal emission from the inner region of the accretion disk. The inferred Eddington ratio ($\epsilon = 3 \pm 1$) is too high for a standard accretion disk. The slim disk can be applied for super-Eddington accretion. The effective temperature of the slim disk can be written as (Wang & Netzer 2003)

$$T_{\text{eff}} = 3.14 \times 10^3 \gamma_0^{1/4} M_{\text{BH}}^{1/4} (r/r_s)^{-1/2} \text{eV},$$  

where $\gamma_0 = (5 + \alpha^2/2)^{1/2}$ is a weak function of the viscosity $\alpha$; $\gamma_0 \approx 2.24$ for $\alpha \ll 1$. We find $T_{\text{eff}} \approx 23$ eV for $r = 3r_s$ and $M_{\text{BH}} = 2 \times 10^7 M_\odot$. However, the derived blackbody temperature from the spectral fitting, $kT_{\text{BB}} = 106 \pm 6$ eV, is much higher than expected. For a thermal origin of the soft X-ray excess, it is difficult to reconcile the BH mass with the blackbody temperature (e.g., a slim disk temperature of 100 eV requires a BH mass of $<10^5 M_\odot$). However, the innermost region of the accretion disk may be very complicated, with features such as a strong outflow developed from the disk itself, as evidenced by PG 1211+143 (Pounds & Page 2006). Comptonization inside the outflow has not been studied but might significantly contribute to the soft X-ray excess. Actually, the temperature holds a constant in the transition layer between the hot corona and the cold disk; it may also make an important contribution to the soft X-ray excess (Nayakshin & Melia 1997). As noted by Gierlin’ski & Done (2004), many AGNs with quite different BH masses have soft X-ray excess with the temperature confined in a very narrow range. This points toward an atomic nature (related to either absorption or reflection) for the soft excess rather than a thermal origin.

Whereas the blackbody model can fit the spectra, our result shows that the fit by the relativistically blurred disk reflection model is better. This supports the possibility that the soft X-ray excess can arise from the disk reflection. The ionization parameter given by the reflection model is large (log $\epsilon = 3.2^{+0.3}_{-0.1}$), implying that the reflection material is highly ionized. The simulation of the X-ray photoionized accretion disk shows that the surface of the accretion disk can be significantly ionized at a high Eddington ratio (Matt et al. 1993). The highly ionized disk surface becomes reflective in the soft X-ray band, producing a steepening X-ray continuum (Haard & Maraschi 1993; Nayakshin et al. 2000; Ballantyne et al. 2001). This scenario is physically plausible for HE 0450–2958.

4.4. X-Ray Properties of Transitional Objects

Canalizo & Stockton (2001) compiled a sample (including HE 0450–2958) of low-redshift ($z \leq 0.4$) objects that are in a transitionary stage between ULIRGs and quasars. Their sample, selected from the intermediate position in the far-infrared color–color diagram between the regions occupied by the two classes of objects from the $\text{IRAS}$ all-sky survey, is nearly complete. We collected the X-ray data of the Canalizo & Stockton (2001) sample, given in Table 3. Of seven X-ray-detected objects, all show steep X-ray photon indices and small X-ray intrinsic absorption, with the exception of Mrk 231, which is heavily obscured. Thus, HE 0450–2958 is very similar to other objects.

In the hierarchical formation paradigm, quasars are formed and fueled via galaxy-galaxy mergers (Kaufmann & Haehnelt 2000; Di Matteo et al. 2005). During the major merger of two

| Name          | $z$ | $\log L_{\text{IR}}/(L_\odot)$ | $\Gamma_{2-10\text{ keV}}$ | $f_{\text{BB}}$ | $N_{\text{H}}^{\text{HI}}$ | Ref. |
|---------------|----|-------------------------------|-----------------------------|-----------------|-----------------|------|
| I Zw1         | 0.061 | 11.97 | 2.31 | 0.09 | 0.02 | 1 |
| 3C 48         | 0.267 | 13.38 | 1.96 | -0.21 | 2 |
| IR 0759+6508  | 0.148 | 12.34 | 2.95 | 0.08 | 0.13 | 3 |
| Mrk 231       | 0.042 | 12.55 | 2.48 | 0.06 | 265 | 4 |
| F00275–2859   | 0.279 | 12.71 | 0.71 | -0.01 | -85 | 5 |
| PG 1700+518   | 0.292 | 12.70 | X-ray | Undetected | 5 |
| HE 0450–2958  | 0.285 | 12.72 | 2.16 | <0.01 | 6 |
| PG 1543+489   | 0.400 | 12.78 | 2.64 | 0.07 | 5.144 | 7 |
| Mrk 1014      | 0.163 | 12.63 | 2.24 | 0.08 | 0 | 1 |

References.—For X-ray data: (1) Piconcelli et al. 2005; (2) Siemiginowska et al. 2003; (3) Imanishi & Terashima 2004; (4) Buitron et al. 2004; (5) George et al. 2000; (6) this work.
comparable galaxies, the quasar is dust-enshrouded and the SMBH growth is obscured by the gas funneled toward a merger nucleus. This picture is supported by a new population of submillimeter and hard X-ray sources at z = 1.5–3 (Chapman et al. 2003; Alexander et al. 2005). When the SMBH reaches a critical mass, the feedback from the SMBH activity expels gas and cleans the obscuring material (Silk & Rees 1998; Fabian 1999; Ciotti & Ostriker 2001). A detailed simulation of galaxy mergers shows that this process creates a window in which the SMBH is observable as an optical quasar for a duration of ~10–20 Myr for a B-band luminosity greater than 10^{11} L_{\odot} (Hopkins et al. 2005). We argue that HE 0450–2958 is just in the beginning of the optical quasar window based on (1) the small X-ray intrinsic absorption, implying that the AGN is dust-cleaned and optically visible; (2) the high accretion rate inferred from the steep X-ray index and the NLS1 nature; and (3) the relatively smaller BH mass compared with optically selected quasars (Hao et al. 2005; Kawakatu et al. 2006).

The IR luminosities of ULIRGs denote intense bursts of star formation and also the “violence” of interactions and mergers (Sanders & Mirabel 1996). The steep X-ray photon indices of AGNs denote the super-Eddington accretion of SMBHs. These ULIRGs associated with AGNs with steep X-ray indices shed new light on the coeval growth of the stellar bulges and SMBHs in the hierarchical paradigm.

5. CONCLUSIONS

The XMM-Newton EPIC spectra of HE 0450–2958 show a substantial soft X-ray excess and a steep photon index, as well as marginal evidence for a weak Fe Kα line. The X-ray absorption is consistent with the Galactic level. The 0.3–10 keV EPIC spectra can be fitted by a power-law plus blackbody model; however, the fit by a relativistically blurred photoionized disk reflection model is better. We estimate a BH mass of $2.1_{-0.3}^{+0.4} \times 10^7 M_{\odot}$ from the X-ray variability. This broadly agrees with the value derived from the optical Hβ line width. These results support a high-state Seyfert galaxy as the source.

HE 0450–2958 shares properties similar to those of transition objects from ULIRGs to quasars. We suggest that HE 0450–2958 is just in the beginning of the optical quasar window.

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