SDSS J1058+5443: A Blue Quasar without Optical/NUV Broad Emission Lines

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Abstract

In this paper, the blue quasar SDSS J105816.19+544310.2 (=SDSS J1058+5443) at redshift 0.479 has been reported as the best true type 2 quasar candidate with the disappearance of central broad-line regions. There are no definite conclusions on the very existence of true type 2 active galactic nuclei (AGN), mainly due to detected optical broad emission lines in high-quality spectra of some previously classified true type 2 AGN candidates. Here, unlike previously reported true type 2 AGN candidates among narrow emission-line galaxies with weak AGN activities but strong stellar lights, the definitely blue quasar SDSS J1058+5443 can be well confirmed as a true type 2 quasar due to apparent quasar-shape blue continuum emissions but an apparent loss of both the optical broad Balmer emission lines and the near-UV (NUV) broad Mg II emission line. Based on different model functions and the F-test statistical technique, after considering blueshifted optical and UV Fe II emissions, there are no apparent broad optical Balmer emission lines and/or broad NUV Mg II lines, and the confidence level is smaller than 1σ in support of broad optical and NUV emission lines. Moreover, assuming the virialization assumption to broad-line emission clouds, the reconstructed broad emission lines strongly indicate that the probable intrinsic broad emission lines, if they exist, cannot be hidden or overwhelmed in the noise of the Sloan Digital Sky Survey spectrum of SDSS J1058+5443. Therefore, SDSS J1058+5443 is so far the best and most robust true type 2 quasar candidate, leading to the clear conclusion of the very existence of true type 2 AGN.

Unified Astronomy Thesaurus concepts: Active galaxies; Active galactic nuclei; Quasars; Supermassive black holes

1. Introduction

Type 1 active galactic nuclei (broad-line AGN) and type 2 AGN (narrow-line AGN) are the two main classes of AGN, due to quite different spectroscopic emission-line features. The constantly improving Unified Model (Antonucci 1993; Netzer 2015) has been widely accepted to explain the different observational phenomena between type 1 and type 2 AGN: central AGN continuum and broad-line emissions from central broad-line regions (BLRs) are widely obscured by central dust torus in type 2 AGN. And the well-detected polarized broad emission lines in type 2 AGN, such as the results well discussed in Antonucci & Miller (1985), Tran (2001), Tran (2003), and Savic et al. (2018), provide robust evidence strongly supporting the Unified Model, indicating that type 1 and type 2 AGN have the same central geometric structures, including similar BLRs, while central BLRs are hidden in type 2 AGN.

Interestingly, based on the pioneering work on the study of polarized broad emission lines in type 2 AGN by Antonucci & Miller (1985), Tran (2001), Tran (2003), Nagao et al. (2004), Cardamone et al. (2007), and followed by Shi et al. (2010), Barth et al. (2014), Zhang (2014), Li et al. (2015), Pons & Watson (2016), and Zhang et al. (2021c), there is one special kind of AGN: true type 2 AGN (or AGN with no hidden BLRs, or BLR-less AGN or unobscured type 2 AGN in the literature) that have no expected hidden central BLRs. There are about 30 Seyfert 2 galaxies with no hidden BLRs reported in Tran (2001), and Tran (2003), due to the lack of polarized broad emission lines. There are two strong true type 2 AGN candidates, NGC3147 and NGC4594, reported in Shi et al. (2010), due to their few X-ray extinctions and the upper limits on the broad emission-line luminosities are two orders of magnitude lower than the average of typical type 1 AGN. A small number of type 2 quasars are reported in Barth et al. (2014) through their strong g-band variabilities. A sample of true type 2 AGN candidates is reported in Zhang (2014) through both their long-term variability and the expected reliable power-law components in their spectra in the Sloan Digital Sky Survey (SDSS). A true type 2 AGN candidate, SDSS J0120, is reported by Li et al. (2015), through its long-term variability properties but with no-detected broad emission lines. A small sample of true type 2 AGN candidates is reported in Pons & Watson (2016) based on their properties of unobscured X-ray emission. More recently, Zhang et al. (2021c) reported the composite galaxy SDSS J1039 as a true type 2 AGN candidate based on its long-term variabilities and its apparent loss of broad optical Balmer emission lines.

Meanwhile, different physical models have been proposed to explain the disappearance of central BLRs, such as the well-reported models in Nicastro et al. (2003), Elitzur & Ho (2009), Cao (2010), Ichikawa et al. (2015), and Elitzur & Netzer (2016), strongly indicating the disappearance of usual central BLRs, depending on physical properties of central AGN activities and/or depending on the properties of the central dust obscuration. Nicastro et al. (2003) showed that the absence or presence of central BLRs can be well regulated by accretion rate, assuming the BLRs were formed by accretion disk instabilities. Elitzur & Ho (2009) proposed a disk-wind scenario to predict the disappearance of the central BLRs at quite low luminosities. Cao (2010) showed that the disappearance of central BLRs associated with the outflows from the...
accretion disks can be expected in AGN with an Eddington ratio smaller than 0.001. Elitzur & Netzer (2016) showed that the disappearance of central BLRs could be expected in AGN with luminosities higher than \(4 \times 10^{46}\) erg s\(^{-1}\) considering mass conservation in the disk outflows.

However, a detailed study on reported true type 2 AGN candidates, i.e., the detailed study of Mrk573 and NGC3147, questions the very existence of true type 2 AGN. Tran (2001) classified Mrk573 as a true type 2 AGN candidate; however, Nagao et al. (2004) showed clearly detected polarized broad Balmer lines, leading Mrk573 to be a normal type 2 AGN with central hidden BLRs. Similarly, Shi et al. (2010), and Bianchi et al. (2012) classified NGC3147 as a true type 2 AGN candidate through both spectropolarimetric results and unobscured X-ray emission properties; however, Bianchi et al. (2019) more recently have clearly detected double-peaked broad H\(\alpha\) in high-quality HST spectrum. Furthermore, Ichikawa et al. (2015) well discussed that no-detected polarized broad emission lines in some true type 2 AGN candidates could probably be due to effects of less scattering medium and/or effects of the increased torus obscurations.

Besides true type 2 AGN with loss of central BLRs as a precious subclass of AGN, there is another precious subclass of AGN: weak-line quasars, which have quite weak broad emission lines in the UV-optical band. Since the first sample of 74 high redshift \((z > 3)\) weak-line quasars from SDSS reported in Diamond-Stanic et al. (2009), weak-line quasars have become interesting targets to provide further clues on accretion disk formation and/or abnormal properties of central BLRs for high ionization emission lines, such as in Shenmer et al. (2010), Plotkin et al. (2015), Marlar et al. (2018), and Paul et al. (2022). However, among the reported weak-line quasars identified by UV emission-line properties, optical Balmer emission-line (H\(\alpha\) and H\(\beta\)) properties have been checked and reported in dozens of weak-line quasars, such as the results in Plotkin et al. (2015) and the reported virial black hole (BH) masses of weak-line quasars by properties of broad Balmer lines in Marculewicz & Nikolajuk (2020), indicating there are apparent broad Balmer emission lines (large rest-frame equivalent widths) in weak-line quasars. Therefore, weak-line quasars with quite weak UV emission lines (especially Ly\(\alpha\) and C IV) but apparent broad Balmer lines are not similar to true type 2 AGN with no-detected broad Balmer lines, so there is no further description or discussion of weak-line quasars in this paper.

There is so far no definite conclusion on the very existence of true type 2 AGN because of lower quality spectra with larger noise being applied to explain the undetected broad emission lines, but detecting true type 2 AGN in high luminous blue AGN would provide clearer clues on the very existence of true type 2 AGN. Here, we report one true type 2 AGN candidate in the blue quasar SDSS J1058+5443 with no-detected broad emission lines, which will provide robust evidence to support the very existence of true type 2 AGN. And due to no-detected broad Balmer lines, there is no further discussion of SDSS J1058+5443 as a weak-line quasar in this paper. Section 2 presents our main results on the spectroscopic properties of SDSS J1058+5443, providing strong evidence in support of the disappearance of broad optical and near-UV (NUV) emission lines. Section 3 provides the properties of the BH mass of SDSS J1058+5443. Section 4 presents our main discussion. Section 5 presents a final summary and our conclusions. We have adopted the cosmological parameters \(H_0 = 70\) km s\(^{-1}\) Mpc\(^{-1}\), \(\Omega_{\Lambda} = 0.7\), and \(\Omega_m = 0.3\).

### 2. Spectroscopic Properties of SDSS J1058+5443

SDSS J1058+5443 at redshift 0.479 is a well-classified blue quasar in the SDSS database, with its spectrum shown in Figure 1. The blue continuum emissions from NUV to near-IR (NIR) can be well described by a power law \(f_\lambda \propto (\lambda/\lambda_0)^{-\alpha}\) with the continuum luminosity at rest wavelength 5100 Å to be \((\lambda L_{\lambda 5100} \sim 5.74 \pm 0.06) \times 10^{44}\) erg s\(^{-1}\), leading SDSS J1058+5443 to definitely be a blue quasar. Meanwhile, the narrow emission lines, especially the apparent [O III]\(\lambda\lambda 4959, 5007\) Å doublet, can be well applied to totally confirm the redshift \(z \sim 0.479\). Moreover, the composite spectrum of SDSS quasars reported in Vanden Berk et al. (2001) is also shown in Figure 1, providing interesting clues on the apparent blue continuum emission features of SDSS J1058+5443. More interestingly, besides the quasar-shape power-law continuum emissions, it looks like there are no broad optical Balmer emission lines and no broad NUV Mg II line but apparent Fe II emissions in SDSS J1058+5443, especially based on the detailed emission features shown around the H\(\beta\), H\(\gamma\), H\(\delta\), and Mg II lines in panels (b)–(e) in Figure 1.

#### 2.1. Properties of Optical Balmer Lines

Besides the direct comparisons between the SDSS spectroscopic emission-line features and the emission-line features in the composite spectrum of SDSS quasars, shown in Figure 1, the detailed properties of the line emissions around the expected broad emission lines are well measured by Gaussian functions as follows. Before proceeding further, there is one point we should note. There is a very broad emission component around 4450 Å, however, so broad component does not exist around H\(\beta\), indicating the broad component should be not from Balmer emission clouds. Therefore, in order to well check the properties of the very broad component around 4450 Å, the emission properties with rest wavelength range from 4200–5400 Å are mainly checked for the emission lines around H\(\beta\) and H\(\gamma\) by the following three different model functions.

For Model A, which assumes the very broad component around 4450 Å as coming from the Balmer emission regions, the following model functions are included. A narrow plus a broad Gaussian function (second moment smaller or larger than 500 km s\(^{-1}\))
\[ G_{\text{HI,3}, B}(\lambda_0, \sigma_0, \sigma_{\beta, N}, f_{\beta, N}) \quad \text{parameter} \lambda_0 \text{ and } \sigma_0 \text{ as central wavelength and second moment in units of angstrom} \]

and\[ G_{\text{HI,3}, B}(\lambda_0, \beta, \sigma_0, \sigma_{\beta, B}, f_{\beta, B}) \]
are applied to describe the H\(\beta\). Narrow and broad Gaussian functions\[ G_{\text{HI,3}, B}(\lambda_0, \gamma, \sigma_0, \sigma_{\gamma, N}, f_{\gamma, N}) \quad \text{and} \quad G_{\text{HI,3}, B}(\lambda_0, \gamma, \sigma_0, \sigma_{\gamma, B}, f_{\gamma, B}) \]
are applied to describe the H\(\gamma\). Two narrow Gaussian functions\[ G_1(\lambda_0, c_1, \sigma_1, f_{c_1}) \quad \text{and} \quad G_2(\lambda_0, c_2, \sigma_2, f_{c_2}) \]
are applied to describe the core components of the [O III]\(\lambda\lambda 4959, 5007\) Å doublet. Two broad Gaussian functions\[ G_1(\lambda_0, c_1, \sigma_1, f_{c_1}) \quad \text{and} \quad G_2(\lambda_0, c_2, \sigma_2, f_{c_2}) \]
are applied to describe the extended components of the [O III] doublet (Greene & Ho 2005a; Shen et al. 2011; Zhang 2013a), considering probably spatially extended emission regions for the outflow-related extended [O III] components as discussed in Zakamska et al. (2016). A broad and a narrow Gaussian functions\[ G_0(\lambda_0, c_2, \sigma_2, f_{c_2}) \quad \text{and} \quad G_1(\lambda_0, c_1, \sigma_1, f_{c_1}) \]
are applied to describe the core and the extended components of the [O III]\(\lambda 4363\) Å. A power-law
component $A \times \left( \frac{\lambda}{4100\text{Å}} \right)^{\beta}$ is applied to describe the continuum emissions underneath the emission lines. When the model functions are applied, the following restrictions are accepted. First, the line flux and second moment of each Gaussian component are not smaller than zero. Second, ratios of the central wavelengths (in units of angstrom) and second moments (in units of angstrom) of $G_{\text{H} \beta, N}$ to $G_{\text{H} \gamma, N}$ are fixed to be

$$\frac{\lambda_{0, \gamma, N}}{4341.68\text{Å}} = \frac{\lambda_{0, \beta, N}}{4862.68\text{Å}}, \quad \frac{\sigma_{0, \gamma, N}}{4341.68\text{Å}} = \frac{\sigma_{0, \beta, N}}{4862.68\text{Å}}.$$  

leading the narrow Balmer lines to have the same redshift and line widths. Third, ratios of the central wavelengths, second moments, and fluxes of $G_{c1}$ to $G_{c2}$ to $G_{c3}$ are fixed to be

$$\frac{\lambda_{0, c1}}{5008.24\text{Å}} = \frac{\lambda_{0, c2}}{4960.295\text{Å}} = \frac{\lambda_{0, c3}}{4364.436\text{Å}}, \quad \frac{\sigma_{0, c1}}{5008.24\text{Å}} = \frac{\sigma_{0, c2}}{4960.295\text{Å}} = \frac{\sigma_{0, c3}}{4364.436\text{Å}}, \quad f_{c1} = 3 \times f_{c2} (f_{c3} \text{ free}).$$  

Fourth, the ratios of the central wavelengths, second moments, and fluxes of $G_{c1}$ to $G_{c2}$ to $G_{c3}$ are fixed to be

$$\frac{\lambda_{0, c1}}{5008.24\text{Å}} = \frac{\lambda_{0, c2}}{4960.295\text{Å}} = \frac{\lambda_{0, c3}}{4364.436\text{Å}}, \quad \frac{\sigma_{0, c1}}{5008.24\text{Å}} = \frac{\sigma_{0, c2}}{4960.295\text{Å}} = \frac{\sigma_{0, c3}}{4364.436\text{Å}}, \quad f_{c1} = 3 \times f_{c2} (f_{c3} \text{ free}).$$  

Figure 1. Panel (a) shows the entire SDSS spectrum of SDSS J1058+5443 (solid dark green line) and the composite spectrum of SDSS quasars (dashed pink line). The dashed red line shows the power-law component to describe the continuum emissions. Panels (b)–(e) show the spectrum (solid dark green line) around the $\text{H}\beta$ (rest wavelength from 4600–5400 Å), $\text{H} \gamma$ (rest wavelength from 4250–4500 Å), $\text{H} \delta$ (rest wavelength from 4000–4200 Å), and $\text{Mg II}$ (rest wavelength from 2600–3100 Å) and the composite spectrum of SDSS quasars (dashed pink line), respectively. Vertical red lines mark the positions of the expected broad $\text{H}\beta$, $\text{H} \gamma$, $\text{H} \delta$, and $\text{Mg II}$ lines in panels (b)–(e).
The model parameters of $G_{H\alpha}$ and $G_{H\beta}$ are free to model parameters, which will provide further clues to the origin of the very broad components around 4450 Å from Balmer emissions or from extended [O III] emissions or other physical origins. Then, through the Levenberg–Marquardt least-squares minimization technique, the best-fitting results to the emission lines obtained using Model A can be well determined, and are shown in Figure 2 with $\chi^2$/dof $\sim$ 0.88 (where $\chi^2$ and dof are the summed squared residuals for the best-fitting results and the degrees of freedom, respectively). Here, in order to show clearer results, the left panel of Figure 2 shows the best-fitting results to the emission lines around $H_\beta$ with a rest wavelength range from 4600–5400 Å, and the right panel of Figure 2 shows the best-fitting results for the emission lines around $H_\gamma$ with the rest wavelength range from 4200–4600 Å.

Before proceeding further, one point is noted. Besides the two narrow Gaussian components for narrow $H_\beta$ and $H_\gamma$ and two broad Gaussian components for broad $H_\beta$ and $H_\gamma$ discussed above, two Gaussian components are also considered in Model A to describe probable outflow components in narrow $H_\beta$ and $H_\gamma$ (the extended component for wings of narrow Balmer lines, such as the broad Gaussian components included in [O III] lines), and two additional Gaussian components are considered in Model A to describe probable outflow components in broad $H_\beta$ and $H_\gamma$ (or to describe probably complicated profiles of broad Balmer lines). However, for the model including the four new additional Gaussian components applied, the determined probable outflow components in broad Balmer lines have fluxes of zero, and the determined outflow components in narrow Balmer lines have their line fluxes one time smaller than their corresponding uncertainties. Therefore, it is not necessary to consider the probable outflow components in narrow Balmer lines or in broad Balmer lines.

The determined parameters of the emission lines obtained using Model A are listed in Table 1. The very broad component around 4450 Å can be well described by a broad Gaussian function with central wavelength 4447 Å, second moment 42 Å, and there is an expected corresponding very broad component underneath $H_\beta$ described by a broad Gaussian function with central wavelength 4912 Å and second moment 95 Å. It is clear that the very broad components coming from very extended components of [O III] emissions can be totally ruled out, mainly due to the following reason. If the very broad component around 4450 Å is from the extended component of [O III]λ4363 Å, the broad component is a redshifted component; however, for

| Line   | $\lambda_0$   | $\sigma$ | Flux     |
|--------|---------------|----------|----------|
| $H_\alpha$ | 4864.56 ± 0.65 | 5.45 ± 0.68 | 38.29 ± 4.86 |
| $H_\beta$ | 4911.72 ± 11.99 | 94.66 ± 9.96 | 296.69 ± 42.51 |
| $H_\gamma$ | 4343.36 ± 0.58 | 4.87 ± 0.61 | 14.16 ± 4.96 |
| $H_\delta$ | 4447.14 ± 3.93 | 41.67 ± 4.92 | 157.07 ± 19.61 |
| [O III]λ5007 | 5009.96 ± 0.15 | 5.88 ± 0.17 | 288.26 ± 10.66 |
| [O III]λ5007 | 4999.51 ± 1.13 | 22.25 ± 1.18 | 350.95 ± 19.03 |
| [O III]λ4363 | 4365.49 ± 0.13 | 5.12 ± 0.15 | 10.02 ± 5.22 |
| [O III]λ4363 | 4356.82 ± 0.98 | 19.39 ± 1.03 | 34.65 ± 14.44 |
| ... | ... | ... | ... |
| opt Fe II | $-7702 ± 256$ | 6200 ± 400 | 991 ± 65 |

Note. [O III]λ5007 and [O III]λ5007 represent the core and the extended components in [O III]λ5007 Å. [O III]λ4363 and [O III]λ4363 represent the core and the extended component in [O III]λ4363 Å. The second and sixth columns show the determined rest central wavelengths in units of angstrom (kilometers per second for the shift velocities of the optical Fe II), and the third and seventh columns show the determined line widths (second moment) in units of angstrom (the broadening velocity in units of kilometers per second for the optical Fe II lines), and the fourth and the eighth columns list the determined line flux in the units of $10^{-17}$ erg s$^{-1}$ cm$^{-2}$.
the component around 4922 Å assumed from the extended component of [O III]λ4959, 5007 Å doublet, it is a blueshifted component. Therefore, the very broad component around 4450 Å is probably from broad Balmer emission lines. However, there are quite different second moments and redshifted velocities (relative to the narrow Balmer lines) of the broad components of Hβ and Hγ, \( \sigma_{\beta} \approx 95 \text{ Å (} \approx 5860 \text{ km s}^{-1} \) but \( \sigma_{\gamma} \approx 42 \text{ Å (} \approx 2900 \text{ km s}^{-1} \) and \( \lambda_{\text{H} \beta} - \lambda_{\text{O} \gamma} \approx 47 \text{ Å (} \approx 2900 \text{ km s}^{-1} \) and \( \lambda_{\text{H} \gamma} - \lambda_{\text{O} \gamma} \approx 104 \text{ Å (} \approx 7170 \text{ km s}^{-1} \), leading to incompatible dynamic properties of broad Balmer emission clouds. Moreover, the measured line width of the very broad component around 4450 Å can also be applied to rule out that the determined extended components of [O III]λ4959, 5007 Å were actually from broad Hβ emissions because the extended component has a line width of about 23–25 Å, 1.9 times smaller than the broad component around 4450 Å. Therefore, the very broad components around 4450 and 4900 Å determined using Model A are not the preferred choice for broad Balmer emission clouds or extended [O III] emission clouds. The preferred choice should mainly be considered for the origin of the very broad components around 4450 Å and around 4910 Å.

With Model B, new model functions are considered as follows. Besides the narrow Balmer emission components and the components from the [O III] emissions described by the Gaussian functions \( G_{\beta \beta}, G_{\gamma \gamma}, G_{\beta \gamma}, G_{\beta \gamma} \) and the AGN continuum emissions described by a power-law function, there is an additional component from optical Fe II emissions described by the broadened optical Fe II template in Kovacevic et al. (2010) that is mainly considered to explain the very broad component around 4450 Å and around 4910 Å. Considering the optical Fe II emission templates in four groups (three groups related to the lower term of the transitions of \( ^4\text{F}, ^6\text{S}, \) and \( ^4\text{G} \) terms, and the fourth group from the I Zw 1 Fe II template) as discussed in Kovacevic et al. (2010), the Fe II component \( G_{\text{Fe}} \) is described by

\[
G_{\text{Fe}} = \sum_{i=1}^{4} I_i \times T_{\text{Fe}, i} \times v_{c} \times v_{b},
\]

where \( I_i \geq 0 \) represents the intensity of Fe II emission features in each group, \( T_{\text{Fe}, i} \) represents the broadened and shifted Fe II emission features in each group, and \( v_{c} \) and \( v_{b} \) mean the same shift velocity and the same broadening velocity for the Fe II emission features in the four groups. Then, the same restrictions applied in Model A are accepted in Model B on the Gaussian components of narrow Balmer emission components and the core and extended components from the [O III] emissions. Then, through the Levenberg–Marquardt least-squares minimization technique, the best-fitting results to the emission lines obtained using Model B can be well determined after considering the optical Fe II emissions, as shown in Figure 3 with \( \chi^2_{\text{fit}}/\text{dof} \approx 1330.88/1329 \). The determined parameters of the emission lines are also listed in Table 1 for Model B. The results obtained with Model B are more natural than those obtained using Model A because there is no need to reconcile the contradiction on the origin of the very broad component around 4450 and 4900 Å. Therefore, in the current stage, Model B is preferred for SDSS J1058+5443, indicating no broad Balmer emission lines in SDSS J1058+5443.

Furthermore, the theoretical flux ratio of Hβ to Hγ is about 2. The determined flux ratios of narrow Hβ to narrow Hγ are about 2.70\(^{+1.98}_{-0.96}\) and 2.78\(^{+1.99}_{-0.72}\) obtained using Model A and
Model B, respectively, consistent with the theoretical value, providing further clues to support the reliability of the determined narrow $H\beta$ and $H\gamma$ components obtained using Model A and Model B.

Moreover, as shown in Table 1 and Figure 3, the Fe II emission line features determined using Model B and the Fe II emission features in the two groups related to the lower term of the transitions of $^4{F}$ and $^6{S}$ in Kovačević et al. (2010) are strongly apparent, but there are quite weak Fe II emission features related to the groups related to the lower term of the transition of $^4{G}$ in Kovačević et al. (2010) and the Fe II template from I Zw 1. Different intensity ratios of optical Fe II features in the four groups in Kovačević et al. (2010) can be found in the examples shown on the webpage http://147.91.240.26/FeII_AGN/link6.html maintained by Dr. Kovačević. And the determined optical Fe II emission features have a blueshifted velocity of about $-7700\text{ km s}^{-1}$ and have an equivalent width (EW) of about 64 Å. The blueshifted velocity is so far the largest blueshift velocity among AGN with optical Fe II lines. However, as discussed in Kovačević et al. (2010), see their Figure 17, there is a negative correlation between the EW of optical Fe II and the EW of [O III] $\lambda 5007$ Å. In SDSS J1058$+5443$, the EW 48 Å of [O III] $\lambda 5007$ Å and the EW 64 Å of optical Fe II are roughly consistent with the EW correlation between optical Fe II and [O III] $\lambda 5007$ Å, to provide further clues to support the determined optical Fe II emission features. Furthermore, as discussed above, only Fe II features in two of the four groups in Kovačević et al. (2010) are strong enough; therefore, the other Fe II templates, such as those discussed in Boroson & Green (1992), Veron-Cetty et al. (2004), and Tsuzuki et al. (2006), cannot efficiently be applied to describe the optical features in SDSS J1058$+5443$, due to partly fixed intensity ratios of optical Fe II features in their templates.

For Model C, based on the results determined using Model B, there are two additional broad Gaussian components, $G_{H\beta}(\lambda_{0,\beta}, \sigma_{\beta}, f_{\beta})$ and $G_{H\gamma}(\lambda_{0,\gamma}, \sigma_{\gamma}, f_{\gamma})$, in Model C applied to describe probable broad Balmer features, besides the optical Fe II emission. When Model C is running, the additional restrictions are accepted on the central wavelengths and second moments of $G_{H\beta}$ and $G_{H\gamma}$,

$$\frac{\lambda_{0,\gamma}}{4341.68\text{ Å}} = \frac{\lambda_{0,\beta}}{4862.68\text{ Å}} = \frac{\sigma_{0,\gamma}}{4341.68\text{ Å}} = \frac{\sigma_{0,\beta}}{4862.68\text{ Å}}$$

(5)

to confirm that the probable broad Balmer lines have the same redshift and the same line widths. Meanwhile, when Model C is running, the determined model parameters of the broadening and shift velocities of the optical Fe II template are accepted as the starting values in Model C, and to assure that the optical Fe II emissions are larger than zero, otherwise, the final results come to be the same results as those obtained using Model A. Then, through the Levenberg–Marquardt least-squares minimization technique, the best-fitting results to the emission lines obtained using Model C can be well determined after considering the probable broad Balmer lines, with $\chi^2_{C}/dof_{C} \sim 1326.69/1325$. The determined broad $H\beta$ can be described by a Gaussian component with central wavelength 4890.68 $\pm$ 45.23 Å, second moment 32.69 $\pm$ 41.56 Å, and flux 13.54 $\pm$ 21.83. And the determined broad $H\gamma$ with line flux zero. The best-fitting results are not shown in plots, but are similar to the results shown in Figure 3, besides the only quite weak broad Gaussian component around 4890.68 Å. Based on the determined line flux and line width being quite smaller than their corresponding uncertainties of $G_{H\beta}$, the determined broad $G_{H\beta}$ is not reliable enough.

Moreover, the F-test technique can be applied to determine that the broad Gaussian component $G_{H\beta}$ determined by Model C is not necessary to be considered. Based on the different $\chi^2/dof$ values for Model C and Model B for optical spectroscopic emissions with and without consideration of probable broad Balmer emission lines, the calculated $F_p$ value is about

$$F_p = \frac{\chi^2_{C} - \chi^2_{B}}{dof_{C} - dof_{B}} \frac{dof_{B}}{dof_{C}} \sim 1.046.$$  

(6)

Based on $dof_{C} - dof_{B}$ and $dof_{C}$ as the number of dofs of the $F$ distribution numerator and denominator, the expected value from the statistical F-test with a confidence level of about 62% will be near $F_p$. Therefore, the confidence level is only about 62%, smaller than 1σ, to support the broad $H\beta$ component, indicating the determined broad Gaussian component obtained using Model C is not preferred. Therefore, based on the shown and discussed results above, no optical broad emission lines can be preferred in SDSS J1058$+5443$.

1. If there were broad $H\beta$ and $H\gamma$ determined using Model A, the expected broad $H\beta$ and $H\gamma$ both have significantly different redshifted velocities and line widths, leading to incompatible dynamic properties of broad Balmer emission clouds.

2. The determined extended components of the [O III] doublet are truly from [O III] emissions, not part of broad $H\beta$ emissions.

3. Considering blueshifted optical Fe II emissions, optical spectroscopic emission features can be naturally described.

4. The F-test technique can be well applied to confirm that it is not necessary to consider broad Balmer lines, once the optical Fe II emissions are fully considered.

### 2.2. Properties of the NUV Mg II Line

Besides properties of the optical Balmer emission lines, emission lines around Mg II with the rest wavelength range from 2600–3600 Å can be well measured by two different models as follows. Here, the selected wavelength range extending to 3600 Å can lead to well-determined continuum emissions.

In Model A, a broadened and shifted UV Fe II template discussed in Kovačević-Dojčinović & Popović (2015) plus a broad Gaussian function and a power-law component are applied to describe the emissions. Here, considering the UV Fe II templates in four groups (four multiplets: 60 within 2907–2979 Å, 61 within 2861–2917 Å, and 62 and 63 that overlap within the range of 2709–2749 Å) as discussed in Kovačević-Dojčinović & Popović (2015), the UV Fe II component $G_{Fe}$ is described by

$$G_{Fe} = \sum_{i=1}^{4} I_i \times T_{Fe, i, V_{ur, V_{ab}}}.$$  

(7)

where $I_i \geq 0$ represents the intensity of UV Fe II emission features in each group, $T_{Fe, i}$ denotes the broadened and shifted UV Fe II emission features in each group, and $V_{ur}$ and $V_{ab}$ denote the same shifted velocity and the same
broadening velocity for the UV Fe II emission features in the four groups. The best-fitting results obtained with Model A are shown in the left panel of Figure 4. The determined broad Mg II has the central wavelength of 2803.61 ± 13.48 Å, second moment 43.86 ± 25.82 Å (≈4700 km s⁻¹), and line flux (355.01 ± 531.71) × 10⁻¹⁷ erg s⁻¹ cm⁻². Considering the measured line flux smaller than the corresponding uncertainty, the determined broad Mg II component is not reliable enough. The measured broadening velocity and blueshifted velocity of the UV Fe II emissions are about 5888 ± 965 km s⁻¹ and −12820 ± 1376 km s⁻¹. And the UV Fe II emission features in the two groups from multiplets 60 and 62 are more strongly apparent than the features from the multiplets 61 and 63.

In Model B with no consideration of a broad Mg II component, only the broadened and shifted UV Fe II template discussed in Kovacevic-Dojcinovic & Popovic (2015) plus a power-law component are applied to describe the emission lines. The best-fitting results obtained using Model B are shown in the right panel of Figure 4. The measured broadening velocity and blueshifted velocity of the UV Fe II emissions are about 6757 ± 239 km s⁻¹ and −14,140 ± 1155 km s⁻¹. And the UV Fe II emission features in the two groups from multiplets 60 and 62 are more strongly apparent than the features from the multiplets 61 and 63. Meanwhile, if the UV Fe II components include apparent effects of central radial flows, the larger blueshifted velocity in UV Fe II emissions than in optical Fe II emissions can be well accepted, after accepted UV Fe II emissions are from regions nearer to the central power source. Model B not considering a broad Gaussian component can also lead to well-accepted best-fitting results to the emission lines around 2800 Å.

Not only are the large uncertainties of line flux and second moments clues to rule out the expected broad Mg II component, the F-test technique can be also applied to determine that it is unnecessary to consider the broad Gaussian component. Based on the different χ²/dof values for Model A and Model B for emission lines around 2800 Å, the calculated F_p value is about

$$F_p = \frac{\chi^2_A - \chi^2_B}{\chi^2_A/\text{dof}_A} \sim 0.62.$$  

Based on dof_A − dof_B and dof_A as the number of dofs of the F distribution numerator and denominator, the expected value from the statistical F-test with a confidence level of about 40% will be near F_p. Therefore, the confidence level is only about 40%, smaller than 1σ, to support the broad Mg II component, indicating the determined broad broad Gaussian component obtained using Model A is not preferred. Certainly, the results discussed above are only based on different model functions and the corresponding F-test technique, further efforts are necessary to totally confirm the results discussed above.

Furthermore, as discussed in Kovacevic-Dojcinovic & Popovic (2015), there is one positive broadening velocity correlation between optical Fe II emission features and UV Fe II features. Based on the determined broadening velocity of about 6700 km s⁻¹ of UV Fe II emission features and the determined broadening velocity of about 6200 km s⁻¹ of optical Fe II emission features in SDSS J1058+5443, there are clues to consider SDSS J1058+5443 to simply follow the broadening velocity correlation between UV and optical Fe II emission features.

### 3. BH Mass of SDSS J1058+5443

BH mass, one of the fundamental parameters of AGN, is mainly estimated in the subsection. BH mass properties will be used in the following subsections to provide further clues to confirm the probable loss of central BLRs in SDSS J1058+5443. Due to no apparent broad emission lines in SDSS J1058+5443, the reported virial BH mass is not considered in this paper based on the virialization assumption applied to broad-line emission clouds (Peterson et al. 2004; Shen et al. 2011). The following two methods are mainly considered.

First, based on the dependence of BH masses on the continuum luminosity reported in Equation (9) in Peterson et al. (2004), the BH mass of SDSS J1058+5443 can be estimated as

$$M_{BH} \propto (\lambda L_{5100})^{0.79±0.09} \sim 3.02^{+1.17}_{-0.84} \times 10^9 M_{\odot}$$  

with the BH mass uncertainty determined by the uncertainty of continuum luminosity and uncertainties of the factors in the equation.

Second, the commonly accepted AGNspec code (Hubeny et al. 2000; Davis et al. 2007) is applied to roughly determine
the central BH mass through properties of spectral energy distributions of SDSS J1058+5443, considering the non-LTE general relativistic accretion disk models. Figure 5 shows the best descriptions of the SDSS spectrum of SDSS J1058+5443 with emission-line features around 2800 Å (from 2700–2950 Å) and around 4900 Å (from 4800–5100 Å) being masked out, with the BH mass \( M_{\text{BH}} \sim (2.5 \pm 1.1) \times 10^8 \, M_\odot \), accretion rate \( \dot{M} \sim 0.03 \pm 0.01 \, M_\odot \, \text{yr}^{-1} \), BH spin \( a_\ast \sim 0.91 \pm 0.06 \), and inclination angle \( \cos(i) \sim 0.32 \pm 0.11 \), through the AGNSPEC code created templates applied through the Levenberg–Marquardt least-squares minimization technique.

The two different methods lead to similar BH mass; therefore, the mean value \( M_{\text{BH}} \sim (2.8 \pm 1.4) \times 10^8 \, M_\odot \) is accepted as the BH mass of SDSS J1058+5443 in the paper.\(^3\)

4. Main Discussion

4.1. Reconstructed Probable Intrinsic but Hidden Broad Balmer Lines?

Based on the estimated BH mass, the intrinsic broad Balmer lines could be reconstructed. Then, it is interesting to check whether the expected intrinsic broad Balmer lines are actually overwhelmed in the noise of the SDSS spectrum of SDSS J1058+5443.

Unlike the previously reported true type 2 AGN candidates, weak broad emission components could lead to no-detected broad emission lines in low-quality spectra with large noise. In the blue quasar SDSS J1058+5443, strong power-law AGN continuum emissions clearly indicate strong intrinsic broad Balmer emission lines, that is if there were broad-line emissions. Based on the strong positive linear correlation (scatter of 0.2 dex) between AGN continuum luminosity and total Balmer line luminosity from the SDSS quasars in Greene & Ho (2005), the expected total H\( \beta \) luminosity (including both the broad and narrow components in H\( \beta \)) of SDSS J1058+5443 could be

\[
L(H\beta) \propto (L_{5100}+1)^{1.133} \sim (1.02 \pm 0.48) \times 10^{43} \, \text{erg s}^{-1}
\]

with uncertainty \( 0.48 \times 10^{43} \, \text{erg s}^{-1} \) determined by the accepted scatter of 0.2 dex of the correlation above. Considering the measured line luminosity of narrow H\( \beta \) of about \((3.57 \pm 0.38) \times 10^{41} \, \text{erg s}^{-1}\) of SDSS J1058+5443, the expected broad H\( \beta \) luminosity (the total H\( \beta \) luminosity minus the narrow H\( \beta \) luminosity) should be about \((9.84 \pm 4.82) \times 10^{42} \, \text{erg s}^{-1}\), the corresponding broad H\( \beta \) line flux is \((1132 \pm 550) \times 10^{-17} \, \text{erg s}^{-1} \, \text{cm}^{-2}\) about 27 times stronger than the narrow H\( \beta \) in SDSS J1058+5443. And due to the strong blue quasar-shape continuum emissions in SDSS J1058+5443, there are no obstructions considered on the line flux of emission lines.

If the expected broad H\( \beta \) with line luminosity of \((9.84 \pm 0.24) \times 10^{42} \, \text{erg s}^{-1}\) was intrinsically true in SDSS J1058+5443, there would have been only one point leading the expected strong broad H\( \beta \) not to have been detected in the SDSS spectrum: the strong broad H\( \beta \) was broad enough that the expected broad H\( \beta \) with much lower heights was totally overwhelmed by the noise of SDSS spectrum. However, considering the estimated BH mass \( M_{\text{BH}} \sim (2.8 \pm 1.4) \times 10^8 \, M_\odot \), the line width \( \sigma_B \) of the expected intrinsic broad Balmer lines can be well estimated through the virialization assumption (Peterson et al. 2004) combined with a size–luminosity empirical relation (Bentz et al. 2013) (scatter of 0.13 dex) to estimate the distance of \( R_{\text{BLR}} \) of BLRs to the central BH,

\[
R_{\text{BLR}} \propto L_{5100}^{0.542} \sim 93 \pm 28 \, \text{lt--days}
\]

\[
\sigma_B(H\beta) = (1.54 R_{\text{BLR}}) \sim 1700 \pm 700 \, \text{km s}^{-1},
\]

where the factor of 5.5 is the applied scale factor to estimate the virial BH mass used in Peterson et al. (2004), and the uncertainty of 28 lt-days of \( R_{\text{BLR}} \) is determined by the scatter of 0.13 dex of the size–luminosity empirical relation, and the uncertainty of 700 km s\(^{-1}\) of \( \sigma_B(H\beta) \) is determined by the uncertainties of both BH mass and \( R_{\text{BLR}} \). Based on the second moment \( \sigma_B(H\beta) = 1700 \pm 700 \, \text{km s}^{-1} \) and the line flux \( f_{\beta}(H\beta) = (1132 \pm 550) \times 10^{-17} \, \text{erg s}^{-1} \, \text{cm}^{-2}\), the expected intrinsic Gaussian-like broad H\( \beta \) \( G_{\lambda\nu}(H\beta) \) with central wavelength \( \lambda_\beta = 4862 \, \text{Å} \) can be well reconstructed, as shown in Figure 6, after considering the uncertainties of the parameters of \( \sigma_B(H\beta) \) and \( f_{\beta}(H\beta) \). It is clear that the expected intrinsic broad H\( \beta \) is strong enough because the intrinsic broad H\( \beta \) cannot be overwhelmed by the noise of the SDSS spectrum.

4.2. Reconstructed Probable Intrinsic but Hidden Broad Mg II Line?

Similar to the procedure to reconstruct intrinsic broad H\( \beta \) (if there was one), the intrinsic broad Mg II can also be reconstructed to check whether the intrinsic broad Mg II line could be hidden or overwhelmed by the noise of the SDSS spectrum, if there was an intrinsic broad Mg II line.
Figure 6. The expected intrinsic broad H$\beta$ through the properties of virial BH mass in SDSS J1058+5443. Symbols and line styles have the same meanings as those shown in Figure 3, but the dashed red line, dotted–dashed purple, dashed purple, dotted–dashed blue, and dashed blue lines show the reconstructed H$\beta$ after considering the intrinsic broad H$\beta$ emission features (if there were any) with Gaussian parameters [\(\lambda_{\text{H} \beta}/\text{Å}, \sigma_{\text{H} \beta}/(\text{km s}^{-1}), f_{\text{H} \beta}/(10^{-17}\text{ erg s}^{-1}\text{ cm}^{-2})\)] as [4862, 1700, 1132], [4862, 1700+700, 1132+550], [4862, 1700+700, 1132+550], and [4862, 1700-700, 1132-550], respectively.

First, based on the strong positive linear correlation (scatter of 0.15 dex) between AGN continuum luminosity at 3000 Å and Mg II line luminosity from the SDSS quasars in Shen et al. (2011) and the measured continuum luminosity at 3000 Å of about \(L_{3000}\sim(8.95\pm0.55)\times10^{44}\text{ erg s}^{-1}\) for SDSS J1058+5443, the expected Mg II line luminosity of SDSS J1058+5443 could be

\[
L(\text{Mg}) \propto (\lambda L_{3000})^{0.909} \sim (1.11 \pm 0.43) \times 10^{43}\text{ erg s}^{-1} (12)
\]

with an uncertainty of \(0.43\times10^{43}\text{ erg s}^{-1}\) determined by the accepted scatter of 0.15 dex of the correlation above, leading the corresponding broad Mg II line flux to be \((1280\pm490)\times10^{-17}\text{ erg s}^{-1}\text{ cm}^{-2}\).

Second, accepting the virialization assumption to broad Mg II emission clouds as discussed in Shen et al. (2011), the line width (FWHM) can be estimated as

\[
\text{FWHM(Mg)} = \left( \frac{M_{\text{BH}}}{5.5 (L_{3000}/10^{44}\text{ erg s}^{-1})^{0.62}} \right)^{0.5}
\]

\[\sim3750 \pm 950\text{ km s}^{-1} (13)\]

with an uncertainty of 950 km s\(^{-1}\) of FWHM(Mg) determined by the uncertainties of both BH mass and \(L_{3000}\), leading to a second moment of about 1590 \(\pm\) 400 km s\(^{-1}\), assuming a Gaussian broad Mg II line. Then, based on second moment \(\sigma(\text{Mg}) = 1590 \pm 400 \text{ km s}^{-1}\) and line flux \(f(\text{Mg}) = (1280 \pm 490) \times 10^{-17}\text{ erg s}^{-1}\text{ cm}^{-2}\) and assumed central wavelength 2800 Å, the expected intrinsic Gaussian-like broad Mg II can be well reconstructed, as shown in Figure 7, after considering the uncertainties of the parameters of \(\sigma(\text{Mg})\) and \(f(\text{Mg})\). It is clear that the expected intrinsic broad Mg II is strong enough, because the intrinsic broad Mg II could not be overwhelmed by the noise of the SDSS spectrum.

Now, based on the reconstructed broad Balmer lines and Mg II line, if there were intrinsic broad emission lines, it would be interesting to compare the expected SDSS spectrum of SDSS J1058+5443 considering the probable intrinsic broad lines and the composite spectrum of SDSS quasars. This comparison is shown in Figure 8. Here, the expected intrinsic broad H$\gamma$ and H$\delta$ are reconstructed based on the reconstructed broad H$\beta$ with line flux ratios of \(f_{\text{H} \gamma}/f_{\text{H} \delta} = 1:0.5:0.3 f_{\text{H} \beta}(=1132 \times 10^{-15}\text{ erg s}^{-1}\text{ cm}^{-2})\) and with the same line width (170 km s\(^{-1}\)) in velocity space and with the same redshift. It is clear that the spectroscopic features considering the expected intrinsic broad lines are totally similar to those of the composite spectrum of SDSS quasars. In a word, if there were intrinsic broad lines, the broad lines could not be hidden or overwhelmed by the noise of the SDSS spectrum in SDSS J1058+5443. Therefore, the loss of broad lines in SDSS J1058+5443 can be clearly confirmed.

4.3. Further Discussion

Besides the detailed discussion of emission lines, the origin of blue continuum emissions is simply considered in this subsection in order to confirm that SDSS J1058+5443 is truly an AGN.

There are two further points applied to confirm that the blue continuum emissions are not from younger stellar objects but from the central AGN activities in SDSS J1058+5443. On the one hand, long-term variabilities of SDSS J1058+5443 have been well checked by an analysis of the 8 yr long light-curve data collected by the Catalina Sky Survey (CSS; Drake et al. 2009), as shown in Figure 9. The apparent variabilities can be well described by the damped random walk (DRW) process (Kelly et al. 2009; Kozlowski et al. 2010; Zu et al. 2013), which has been proved to be the preferred process to describe intrinsic AGN variabilities. Through the public code of JAVELIN, the determined DRW process parameter of the characteristic variability timescale is about \(\ln(\tau/\text{days}) \sim 4.95 \pm 0.54 (\tau \sim 140\ \text{days})\), similar to the mean value of \(\tau\) in SDSS quasars as is well discussed in MacLeod et al. (2010). On the other hand, the determined flux ratio of the total [O III]\(\lambda 5007\) Å (both the core and broad component) to the narrow H$\beta$ is about 16.3 larger than 10, 

Figure 7. The expected intrinsic broad Mg II through the properties of virial BH mass in SDSS J1058+5443. Symbols and line styles have the same meanings as those shown in the right panel of Figure 4, while the dashed red, dotted–dashed purple, dashed purple, dotted–dashed blue, and dashed blue lines show the reconstructed intrinsic broad Mg II emission features (if there were any) after considering the intrinsic broad Mg II emission features (if there were any) with Gaussian parameters [\(\lambda_{\text{Mg II}}/\text{Å}, \sigma(\text{Mg II})/(\text{km s}^{-1}), f(\text{Mg II})/(10^{-17}\text{ erg s}^{-1}\text{ cm}^{-2})\)] as [2800, 1590, 1280], [2800, 1590+400, 1280+490], [2800, 1590+400, 1280-490], [2800, 1590-400, 1280+490], and [2800, 1590-400, 1280-490], respectively.
indicating strong central AGN activities in SDSS J1058+5443 by applications of BPT diagrams (Kewley et al. 2019; Zhang et al. 2020). Therefore, the apparently blue continuum emissions are confirmed to be from central AGN activities. Then, due to the strong blue continuum emissions from central AGN activities, we do not discuss the loss of broad emission lines due to SDSS J1058+5443 classified as a changing-look AGN at a dim state (Tohline & Osterbrock 1976; LaMassa et al. 2015; Yang et al. 2018; Zhang 2021b).

Moreover, the no-detected broad emission lines are not due to SDSS J1058+5443 as a BL Lac (Plotkin et al. 2008). The radio properties of SDSS J1058+5443 have been well checked using data from the Faint Images of the Radio Sky at Twenty-cm (Helfand et al. 2015). The radio intensity at 1.4 GHz is about 17.7 mJy in SDSS J1058+5443, leading SDSS J1058+5443 to be a radio-loud AGN with radio loudness of about 29. However, [O III] 5007 Å has a rest EW of about 49 Å, much larger than 5 Å, indicating SDSS J1058+5443 is not a BL Lac object but a normal radio-loud quasar.

4.4. What Should Be Done in the Near Future?

Actually, there is one surefire way to confirm SDSS J1058+5443 as a true type 2 AGN. Obtaining the spectroscopic observations around Hα would provide robust evidence to support the conclusions in this paper for SDSS J1058+5443. If there were no broad components of Hα, SDSS J1058+5443 would be classified as a true type 2 AGN. We hope that there will be the opportunity to obtain NIR spectroscopic observations of SDSS J1058+5443 in the near future.

4.5. Physical Origin of the Loss of Central Normal BLRs in SDSS J1058+5443

Once the loss of broad emission lines is confirmed, it is interesting to consider the potential physical origin of the loss of central normal BLRs. In SDSS J1058+5443 with bolometric luminosity of about $6-9 \times 10^{45}$ erg s$^{-1}$ (about 10 times the continuum luminosity $L_{\lambda(5100)}$ (Netzer 2019), both the steep bluer power-law AGN continuum emissions and the strong bolometric luminosity indicate that the disk-wind scenario with luminosities higher than $10^{46}$ erg s$^{-1}$ as well discussed in Elitzur & Netzer (2016) can be well applied to explain the loss.
of broad emission lines in SDSS J1058+5443, rather than the accreting process with lower accretion rates as discussed in Cao (2010), Nicastro et al. (2003), Elitzur & Ho (2009), etc. And the apparent blueshifted broad UV and OPT Fe II emission lines and the AGNSPEC simply determined large $a_*$ of 0.91 can provide probable clues to support the expected disk-wind scenario in Elitzur & Netzer (2016).

One point should be noted. As discussed in Villar Martin et al. (2020), there is a special subclass of AGN, called core-extremely red quasars (core-ERQs) previously defined in Hamann et al. (2017), representing an intermediate evolutionary phase in which a heavily obscured quasar is blowing out circumnuclear interstellar medium, leading to commonly consequent extreme outflows in high luminosity core-ERQs. In other words, the conditions of the disk-wind scenario discussed in Elitzur & Netzer (2016) could be well satisfied in high luminosity core-ERQs; however, there are common BLRs in core-ERQs. Therefore, the proposed disk-wind scenario discussed in Elitzur & Netzer (2016) can be applied to explain the disappearance of central BLRs, but cannot be accepted as a standard criterion leading to the disappearance of central BLRs in AGN.

5. Summary and Conclusions

Finally, our main conclusions are as follows:

1. SDSS J1058+5443 is a blue quasar with apparently blue continuum emissions coming from central AGN activities, based on the DRW process well-determined long-term variabilities and a flux ratio larger than 10 of [O III] to narrow H/3 of SDSS J1058+5443. Unlike previously reported true type 2 AGN candidates among emission-line objects with weak AGN activities but a strong host galaxy contribution, the properties of SDSS J1058+5443 could provide more robust evidence to support the very existence of true type 2 AGN.

2. Considering different model functions applied to describe the emission lines around H/3, rather than broad Balmer lines but blueshifted optical Fe II emissions is preferred in SDSS J1058+5443, leading to the conclusion that there are no broad optical Balmer emission lines in SDSS J1058+5443. The confidence level is smaller than 1σ to support the probable existence of broad Balmer emission lines.

3. Considering the different model functions applied to describe emission lines around 2800 Å in SDSS J1058+5443, the blueshifted UV Fe II emissions can be preferred in SDSS J1058+5443, leading to the conclusion that there is no broad NUV Mg II line in SDSS J1058+5443. The confidence level is smaller than 1σ to support the probable existence of a broad NUV Mg II line.

4. Considering the virialization assumption of broad emission clouds in SDSS J1058+5443, combined with the estimated BH mass, the expected intrinsic broad optical Balmer lines and NUV Mg II line can be well reconstructed if there were intrinsic broad emission lines in SDSS J1058+5443. The SDSS spectrum plus reconstructed broad lines are similar to the composite spectrum of SDSS quasars.

5. The reconstructed intrinsic broad lines cannot be hidden or overwhelmed by the noise of the SDSS spectrum of SDSS J1058+5443, indicating the loss of broad emission lines is not due to spectral quality.

6. The SDSS J1058+5443 is so far the best true type 2 quasar candidate, confirming to the very existence of true type 2 AGN. And the expected disk-winds scenario with high luminosity could be preferred to explain the loss of central BLRs in SDSS J1058+5443.

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