Dependence of 4000 Å Break Strength on Narrow Emission Line Properties in Local Type-2 AGN (Postprint)

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Abstract

In this manuscript, we report evidence to support the dependence of Dn4000 (4000 Å break strength to trace stellar ages) on central active galactic nuclei (AGN) activity traced by narrow emission line properties in local Type-2 AGN in SDSS DR16. Based on the measured Dn4000 and flux ratios of [O iii] to narrow Hβ (O3HB) and [N ii] to narrow Hα (N2HA) and narrow Hα line luminosity LHα, linear dependence of the Dn4000 on the O3HB, N2HA and LHα in the local Type-2 AGN can provide clues to support the dependence of Dn4000 on properties with narrow emission lines. Linear correlations between the Dn4000 and the O3HB and N2HA can be found in the local Type-2 AGN, with Spearman rank correlations of about −0.39 and 0.53. Meanwhile, stronger dependence of the Dn4000 on the LHα can be confirmed in Type-2 AGN, with a Spearman rank correlation coefficient of about −0.7. Moreover, combining the LHα and the N2HA, a more robust and stronger linear correlation can be confirmed between the Dn4000 and the new parameter , with a Spearman rank correlation coefficient of about −0.76 and with smaller rms scatters. After considering necessary effects,the dependence of Dn4000 on LR is stable and robust enough for the local Type-2 AGN,indicating that the LR on the narrow emission lines can be treated as a better indicator to statistically trace stellar ages of samples of more luminous AGN with weaker host galaxy absorption features.

Full Text

Preamble

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Dependence of 4000 Å Break Strength on Narrow Emission Line Properties in Local Type-2 AGN

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Abstract

We report evidence for a dependence of Dn4000 (the 4000 Å break strength, which traces stellar ages) on central active galactic nucleus (AGN) activity as traced by narrow emission line properties in local Type-2 AGN from SDSS DR16. Our measurements of Dn4000 and the flux ratios [O III]/narrow Hβ (O3HB), [N II]/narrow Hα (N2HA), and the narrow Hα line luminosity (LHα) reveal linear dependencies of Dn4000 on these parameters in local Type-2 AGN. We find significant correlations between Dn4000 and both O3HB and N2HA, with Spearman rank correlation coefficients of approximately -0.39 and 0.53, respectively. Meanwhile, an even stronger dependence of Dn4000 on LHα is confirmed in Type-2 AGN, with a Spearman rank correlation coefficient of about -0.7.

Furthermore, by combining LHα and N2HA, we confirm a more robust and stronger linear correlation between Dn4000 and the new parameter LR, achieving a Spearman rank correlation coefficient of about -0.76 with smaller RMS scatters. After accounting for necessary effects, this dependence of Dn4000 on LR remains stable and robust for local Type-2 AGN, indicating that LR based on narrow emission lines can serve as a superior statistical indicator for tracing the stellar ages of samples containing more luminous AGN with weaker host galaxy absorption features.

Key words: galaxies: active – galaxies: nuclei – (galaxies:) quasars: emission lines – galaxies: Seyfert

1. Introduction

Tight connections between active galactic nuclei (AGN) and host galaxies are expected due to AGN feedback through galactic-scale outflows playing key roles in galaxy evolution (McNamara & Nulsen 2007; Fabian 2012; Kormendy & Ho 2013; Heckman & Best 2014; King & Pounds 2015; Tombesi et al. 2015; Muller-Sanchez et al. 2018). Both negative and positive AGN feedback on star formation in AGN host galaxies have been reported in observational and theoretical studies, with clear evidence for negative feedback presented in Feruglio et al. (2010), Page et al. (2012), Wylezalek & Zakamska (2016), Comerford et al. (2020), and Zhang (2024a), and positive feedback discussed in Zubovas et al. (2013), Zinn et al. (2013), and Shin et al. (2019). Given these contrary conclusions regarding AGN feedback effects, it is valuable to provide further clues through different methodological approaches.

Beyond direct measurements of star formation, AGN feedback should have apparent and strong effects on stellar ages in AGN host galaxies. Various methods have been proposed to determine mean stellar ages. Cid Fernandes et al. (2005) demonstrated measurements of light-weighted mean stellar ages using the STARLIGHT code based on simple stellar population (SSP) methods (Bruzual & Charlot 1993). Cappellari (2017) showed that the penalized pixel-fitting method can yield reliable and smoother star formation histories when regularization is applied, leading to estimates of mass-weighted stellar ages. Kauffmann et al. (2003b) estimated mean stellar ages using the Dn4000 parameter (4000 Å break strength) as a tracer of star formation histories, with similar discussions found in Zahid et al. (2015). More recently, Greene et al. (2020) reported a loose dependence of Dn4000 on [O III] line luminosity, suggesting that narrow line luminosity could be roughly applied to trace stellar age properties.

Therefore, reliable methods exist for estimating stellar ages in AGN host galaxies. To obtain clear estimates, host galaxy features should be significantly prominent, making Type-2 AGN (narrow emission line AGN) better candidates than Type-1 AGN (broad line AGN) for studying the effects of AGN activity on stellar ages. Moreover, based on the commonly accepted unified model of AGN (Netzer 2015; Suh et al. 2019), emissions from central accretion disks and broad emission line regions are completely obscured by the central dust torus in Type-2 AGN. This means that both spectroscopic continuum emissions and absorption features in Type-2 AGN can be clearly applied to measure mean stellar ages with minimal contamination.

In addition to the host galaxy features in Type-2 AGN for determining stellar ages via the Dn4000 parameter (our primary focus), AGN activity in Type-2 AGN can be well traced by narrow emission line properties in the well-known BPT diagrams (Baldwin et al. 1981; Kewley et al. 2001; Kauffmann et al. 2003a; Kewley et al. 2006, 2019; Zhang et al. 2020). These conditions enable research on the potential dependence of stellar ages on central AGN activity using a large sample of Type-2 AGN, providing clear clues about AGN feedback effects.

This manuscript is organized as follows. Section 2 presents the Type-2 AGN data samples and our procedure for measuring the Dn4000 parameter. Section 3 presents our main results and discussions. Section 4 provides our final summary and conclusions. Throughout this manuscript, we adopt cosmological parameters of $H_0 = 70$ km s^{-1} Mpc^{-1}, Ω_Λ = 0.7, and Ω_m = 0.3.

2. Data Samples of Type-2 AGN

We first collected 87,828 low-redshift narrow emission line galaxies from the main galaxy sample in SDSS DR16 (Sloan Digital Sky Survey, Data Release 16; Ahumada et al. 2020) as our parent sample. These galaxies have redshifts less than 0.35, median spectral signal-to-noise ratios (S/N) greater than 10, reliable SDSS-provided narrow emission lines of Hβ, [O III], Hα, and [N II], reliable SDSS pipeline-measured stellar velocity dispersions, and Balmer decrements (flux ratio of narrow Hα to narrow Hβ) less than 6. The SDSS pipeline-provided emission line parameters were collected from the "GalSpecLine" database reported by MPA-JHU (Brinchmann et al. 2004; Tremonti et al. 2004; Kauffmann et al. 2003b), while Dn4000 values were collected from the public SDSS database "GalSpecIndx."

In addition to the SDSS pipeline values, we re-measured both emission line parameters and Dn4000. Narrow emission lines were re-measured in the collected narrow emission line objects after subtracting host galaxy contributions to confirm the reliability of the narrow emission line parameters. Following our recent work (Zhang 2021a, 2021b, 2021c, 2022a, 2022b, 2023, 2024a), we applied two main steps. First, we determined host galaxy contributions using the SSP method (Bruzual & Charlot 1993; Cid Fernandes et al. 2005; Kauffmann et al. 2003b; Cappellari 2017). Second, we measured emission lines using multiple Gaussian functions in the line spectrum after host galaxy subtraction. While we omit detailed discussions of the SSP method and emission line measurements here, Figure 1 shows an example of the host galaxy contributions determined by the SSP method in the inverse variance weighted mean spectrum of the collected Type-2 AGN, along with the best-fitting results to the emission lines obtained through the Levenberg–Marquardt least-squares minimization technique. Although we do not discuss the measured line parameters in detail, our values are quite consistent with those reported in "GalSpecLine" for narrow emission line galaxies, with Spearman rank correlation coefficients larger than 0.93, supporting the reliability of our measured emission line parameters.

Furthermore, besides the Dn4000 parameter provided by the "GalSpecIndx" database (parameter d4000_n), we re-measured Dn4000 using downloaded SDSS spectra. The 4000 Å break strength was measured using the definition described in Balogh et al. (1999) and Kauffmann et al. (2003b), with ConB and ConR representing the mean continuum emission intensities within the rest wavelength ranges 3850–3950 Å and 4000–4100 Å, respectively. Although we do not discuss our measured Dn4000 values in detail, they are quite consistent with those reported in "GalSpecIndx" for narrow emission line galaxies, with a Spearman rank correlation coefficient larger than 0.9, supporting the reliability of our measurements.

Based on the measured narrow line emission flux ratios [O III]\$ $5007 tonarrowH$ \$ (O3HB) and [N II]\$ $6583 tonarrowH$ \$ (N2HA) used in the BPT diagram, we adopted the dividing line from Kewley et al. (2001) to collect 14,031 Type-2

AGN and exclude composite objects. The mean spectrum of these 14,031 Type-2 AGN is shown in the left panel of Figure 1. Meanwhile, we used the dividing line from Kauffmann et al. (2003a) to collect 44,501 H II galaxies and exclude composite objects from our H II galaxy sample. The BPT diagram of O3HB versus N2HA with the applied dividing lines is shown in Figure 2.

With the measured Dn4000 and narrow emission line parameters, we investigated the dependence of Dn4000 on narrow emission line properties.

3. Main Results and Discussions

For the collected 14,031 Type-2 AGN, correlations between Dn4000 and log O3HB and between Dn4000 and log N2HA are shown in the top panels of Figure 3. The Spearman rank correlation coefficients are approximately −0.39 (P_{null} < 10^{-15}) and 0.53 (P_{null} < 10^{-15}) for Dn4000 versus O3HB and Dn4000 versus N2HA, respectively, indicating that Dn4000 depends more sensitively on N2HA than on O3HB. For the stronger correlation between Dn4000 and log N2HA in Type-2 AGN, we determined the best-fitting results using the commonly applied least trimmed squares (LTS) robust technique (Cappellari et al. 2013; Mahdi & Mohammad 2017), yielding Dn4000 = 1.65 + 0.011 log N2HA with an RMS scatter of about 0.174. Since larger O3HB values indicate stronger central AGN activity, Type-2 AGN with stronger AGN activity (larger O3HB) should have younger stellar ages, consistent with the conclusions of Kauffmann et al. (2003a) that host galaxies of high-luminosity AGN have much younger mean stellar ages.

We also examined the dependence of Dn4000 on O3HB and N2HA in the collected 44,501 H II galaxies, shown in the bottom panels of Figure 3. The Spearman rank correlation coefficients are approximately 0.01 (P_{null} < 10^{-15}) and 0.37 (P_{null} < 10^{-15}) for Dn4000 versus O3HB and Dn4000 versus N2HA in H II galaxies, respectively, indicating weak dependence of Dn4000 on narrow line flux ratios in these objects. Furthermore, as shown in Figure 3, the N2HA ranges are similar between Type-2 AGN (with log N2HA spanning approximately 0.25) and H II galaxies (with log N2HA spanning approximately 0.3). Therefore, the different dependence of Dn4000 on N2HA between Type-2 AGN and H II galaxies is not due to different spans of the N2HA parameter. In fact, the span of log N2HA is slightly larger in Type-2 AGN; if span effects were significant, we would expect a looser dependence of Dn4000 on N2HA in Type-2 AGN.

Beyond the dependence on O3HB and N2HA used in the BPT diagrams, we also examined the dependence of Dn4000 on narrow line luminosities in both Type-2 AGN and H II galaxies, as shown in Figure 4. The correlations between Dn4000 and [O III]$ 5007 line luminosity (L_{O3}) have Spearman rank correlation coefficients of approximately −0.66 ($P_{null} < 10${-15}) and −0.53 ($P_{null} < 10${-15}) in Type−2 AGN and H II galaxies, respectively. The correlations bet line luminosity (L_Hα) have Spearman rank correlation coefficients of approximately −0.70 (P_{null} < 10^{-15}) and −0.55 (P_{null} < 10^{-15}) in

Type-2 AGN and H II galaxies, respectively. For the stronger correlations between Dn4000 and L_Hα and between Dn4000 and L_{O3} in Type-2 AGN, we determined the corresponding best-fitting results using the LTS robust technique, yielding Dn4000 = 1.65 − 0.002 log L_Hα and Dn4000 = 1.65 − 0.002 log L_{O3}, with RMS scatters of about 0.143 and 0.155, respectively.

In Type-2 AGN, the dependence of Dn4000 on N2HA and narrow Hα line luminosity is apparent, with linear correlation coefficients of 0.53 and −0.70, but these correlations are not sufficiently strong. We therefore investigated whether combining narrow emission line flux ratios and emission line luminosities could produce a stronger linear correlation with the Dn4000 parameter. We defined a new parameter LR as LR = 0.2 log L_Hα − 0.5 log N2HA. The left panel of Figure 5 shows the correlation between Dn4000 and this new parameter LR in Type-2 AGN, with a Spearman rank correlation coefficient of approximately −0.76 (P_{null} $< 10^{-15}$). The right panel of Figure 5 shows the correlation between Dn4000 and LR in H II galaxies, with a Spearman rank correlation coefficient of approximately −0.65 (P_{null} $< 10^{-15}$). The correlations between Dn4000 and LR in both Type-2 AGN and H II galaxies can be determined by the LTS robust technique, yielding Dn4000 = 1.65 − 0.007 L_R with RMS scatters of about 0.125 and 0.069, respectively.

To optimize the LR parameter, we randomly sampled values of A and B from −10 to 10 in the formula LR = A log L_Hα + B log N2HA and calculated the corresponding Spearman rank correlation coefficients for the correlation between LR and Dn4000. The maximum correlation coefficient occurs at A = 0.2 and B = −0.5. Among all emission line parameters, this LR parameter combining Hα luminosity and N2HA produces the strongest linear correlation with Dn4000. We do not discuss LR parameters combining other narrow emission line properties.

In addition to the results discussed above, we note that LINERs (low-ionization nuclear emission line regions; Heckman 1980; Filippenko & Terlevich 1992; Dopita & Sutherland 1996; Marquez et al. 2017) are included in our Type-2 AGN sample. LINERs and Seyfert-2 galaxies occupy two distinct sub-branches in BPT diagrams. Therefore, it is necessary to check whether LINERs affect our results on Dn4000. While we do not discuss whether LINERs are genuine AGN, their classification in BPT diagrams has been well discussed in Groves et al. (2006), Kewley et al. (2006), Juneau et al. (2011), Coldwell et al. (2018), and Agostino et al. (2021). In the O3HB versus N2HA BPT diagram shown in Figure 2, we classify 4,134 LINERs as objects lying above the dashed green line and below the solid purple line. We adopt the classification scheme using the dividing lines in the O3HB versus S2HA (flux ratio of [S II] to narrow Hα) diagram from Kewley et al. (2006), which roughly corresponds to the purple solid line in Figure 2 for the O3HB versus N2HA diagram.

Figure 6 shows the dependence of Dn4000 in the 9,897 Seyfert-2 galaxies and 4,134 LINERs. The correlations between Dn4000 and N2HA have Spearman rank correlation coefficients of approximately 0.40 (P_{null} $< 10^{-15}$) and 0.25

(P_{null} $< 10^{-15}$) in Seyfert-2 galaxies and LINERs, respectively. The correlations between Dn4000 and L_Hα have Spearman rank correlation coefficients of approximately -0.66 (P_{null} $< 10^{-15}$) and -0.37 (P_{null} $< 10^{-15}$) in Seyfert-2 galaxies and LINERs, respectively. The correlations between Dn4000 and LR have Spearman rank correlation coefficients of approximately -0.72 (P_{null} $< 10^{-15}$) and -0.42 (P_{null} $< 10^{-15}$) in Seyfert-2 galaxies and LINERs, respectively. These very different correlations likely indicate that LINERs have unique physical properties distinct from Seyfert-2 galaxies. The linear correlations in the 9,897 Seyfert-2 galaxies can be determined by the LTS technique as Dn4000 = 1.65 + 0.012 log N2HA, Dn4000 = 1.65 − 0.002 log L_Hα, and Dn4000 = 1.65 − 0.008 L_R, with RMS scatters of about 0.151, 0.121, and 0.107, respectively. Clearly, LINERs have minimal effects on our results regarding the dependence of Dn4000 on emission line parameters in Type-2 AGN. Meanwhile, emission line properties are much weaker in LINERs than in normal Seyfert-2 galaxies.

Before concluding this section, we note seven additional points regarding potential systematic effects.

First, we discuss the effects of spectral signal-to-noise ratio (S/N) on our results. Since we only consider low-redshift narrow emission line Type-2 AGN with S/N $>$ 10 (as discussed in Section 2), we verified our results using a higher S/N subsample. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), we examined correlations between Dn4000 and N2HA, Dn4000 and L_Hα, and Dn4000 and LR for the 3,503 Seyfert-2 galaxies with S/N $>$ 20. The correlations have Spearman rank correlation coefficients of approximately 0.34 (P_{null} $< 10^{-15}$), -0.67 (P_{null} $< 10^{-15}$), and -0.71 (P_{null} $< 10^{-15}$), respectively. While we do not show these correlations explicitly, they are fully consistent with our results for the full sample of 9,897 Seyfert-2 galaxies, indicating that spectral S/N has minimal effect on our final results.

Second, we checked for effects of redshift on the Dn4000–LR correlation in Type-2 AGN. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), we examined the correlation between Dn4000 and LR for 4,581 galaxies with z $>$ 0.1 (Spearman rank correlation coefficient of -0.68 with P_{null} $< 10^{-15}$) and 5,316 galaxies with z $<$ 0.1 (Spearman rank correlation coefficient of -0.69 with P_{null} $< 10^{-15}$). The critical value z 0.1 was chosen to produce similar sample sizes. Figure 7 shows these correlations with LTS-determined linear relations described by Dn4000 = 1.65 − 0.014 L_R, with RMS scatters of about 0.116 and 0.096, respectively. These results are well consistent with those for the full sample of 9,897 Seyfert-2 galaxies, indicating no evolution effects on the correlation between Dn4000 and LR for Type-2 AGN with redshift less than 0.35.

Third, we examined whether the Dn4000–LR correlation in Type-2 AGN depends on central activity as traced by O3HB. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), we analyzed the Dn4000–LR correlation for 4,925 galaxies with log O3HB $>$ 0.56 (Spearman rank correlation coefficient of -0.77 with

P_{null} < 10^{-15}) and 4,972 galaxies with log O3HB < 0.56 (Spearman rank correlation coefficient of −0.68 with P_{null} < 10^{-15}). The critical value of 0.56 was chosen to produce similar sample sizes. Figure 8 shows these correlations with LTS-determined linear relations described by Dn4000 = 1.65 − 0.008 L_R, with RMS scatters of about 0.104 and 0.112, respectively. These results are well consistent with those for the full sample, indicating that the Dn4000–LR correlation does not depend on central activity for Type-2 AGN in the BPT diagram.

Fourth, we checked for possible effects of the N2HA range on the Dn4000–LR dependence. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), we examined the Dn4000–LR correlation for 4,987 galaxies with log N2HA > −0.091 (Spearman rank correlation coefficient of −0.72 with P_{null} < 10^{-15}) and 4,910 galaxies with log N2HA < −0.091 (Spearman rank correlation coefficient of −0.62 with P_{null} < 10^{-15}). The critical value was chosen to produce similar sample sizes. Figure 9 shows these correlations with LTS-determined linear relations described by Dn4000 = 1.65 − 0.015 L_R, with RMS scatters of about 0.099 and 0.116, respectively. These results are well consistent with those for the full sample, indicating that the N2HA range does not affect the Dn4000–LR dependence for Type-2 AGN in the BPT diagram.

Fifth, we examined whether the Dn4000–LR correlation in Type-2 AGN depends on host galaxy morphology as traced by the inverse concentration parameter IC = R_{50}/R_{90}, where R_{50} and R_{90} represent the radii containing 50% and 90% of the Petrosian flux in the SDSS r band. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), 9,853 have reliable SDSS pipeline parameters R_{50} and R_{90} (parameters "petroR50_r" and "petroR90_r" in the SDSS "PHOTOOBJALL" database). We examined the Dn4000–LR correlation for 4,943 galaxies with IC < 0.374 (Spearman rank correlation coefficient of −0.71 with P_{null} < 10^{-15}) and 4,910 galaxies with IC > 0.374 (Spearman rank correlation coefficient of −0.73 with P_{null} < 10^{-15}). The critical value IC 0.374 was chosen to produce similar sample sizes. Figure 10 shows these correlations with LTS-determined linear relations described by Dn4000 = 1.65 − 0.011 L_R, with RMS scatters of about 0.122 and 0.095, respectively. These results are quite consistent with those for the full sample, indicating that the Dn4000–LR correlation does not depend on host galaxy morphology.

Sixth, we examined whether the Dn4000–LR correlation in Type-2 AGN depends on stellar velocity dispersion σ. *Considering the tight connection between stellar velocity dispersion and central black hole mass (the M–σ relation; Ferrarese & Merritt 2000; Gebhardt et al. 2000; Kormendy & Ho 2013; McConnell & Ma 2013) and between total stellar mass and central black hole mass (Marconi & Hunt 2003; Haring & Rix 2004; Kormendy & Ho 2013; McConnell & Ma 2013; Suh et al. 2020), any dependence on stellar velocity dispersion would provide clues about the effects of black hole mass and total stellar mass on the Dn4000–LR correlation. Among the 9,897 Seyfert-2 galaxies (excluding LINERs), we examined the Dn4000–LR correlation for 4,877 galaxies with* σ <

135 km s^{-1} (Spearman rank correlation coefficient of -0.76 with P_{null} < 10^{-15}) and 5,020 galaxies with $\sigma^* > 135$ km s^{-1} (Spearman rank correlation coefficient of -0.77 with P_{null} < 10^{-15}). The critical value σ^* 135 km s^{-1} was chosen to produce similar sample sizes. Figure 11 shows these correlations with LTS-determined linear relations described by Dn4000 = 1.65 − 0.012 L_R, with RMS scatters of about 0.095 and 0.105, respectively. These results are consistent with those for the full sample, indicating that the Dn4000–LR correlation does not depend on host galaxy stellar velocity dispersion.

Seventh, motivated by the reported dependence of Dn4000 on total stellar mass (Kauffmann et al. 2003a; Zahid & Geller 2017), we investigated whether the parameter LR or total stellar mass M* better traces Dn4000. We used the public database "StellarMassPCAWiscBC03" (Chen et al. 2012) from the MPA/JHU research group to collect measured total stellar masses for narrow emission line galaxies in SDSS. Figure 12 shows the dependence of Dn4000 on total stellar mass for the 9,897 Seyfert-2 galaxies (excluding LINERs) and 44,501 H II galaxies, with Spearman rank correlation coefficients of approximately 0.15 (P_{null} < 10^{-15}) and 0.39 (P_{null} < 10^{-15}), respectively. These results are consistent with Kauffmann et al. (2003a), who found that strong AGN (here, Seyfert-2 galaxies) show weak dependence of Dn4000 on M. *Due to this weak dependence, we do not provide a formulaic description. The different dependence of Dn4000 on M* between Seyfert-2 galaxies and H II galaxies may result from AGN feedback causing host galaxy evolution in AGN to differ from normal quiescent galaxy evolution. While discussing these differences is beyond the scope of this manuscript, our results support that total stellar mass can only reliably trace stellar age (Dn4000) in quiescent galaxies, whereas the LR parameter can efficiently trace stellar age (Dn4000) in both AGN and non-AGN galaxies.

4. Summary and Conclusions

Our main findings are summarized as follows:

1. Based on well-measured narrow emission lines from low-redshift narrow emission line galaxies in SDSS DR16, we assembled large samples of 14,031 Type-2 AGN and 44,501 H II galaxies using the BPT diagram of O3HB versus N2HA.

2. We confirm a strong positive correlation between Dn4000 and N2HA and a negative correlation between Dn4000 and O3HB in Type-2 AGN. However, weaker corresponding correlations between Dn4000 and narrow emission line ratios are detected in H II galaxies.

3. Strong negative correlations are confirmed between Dn4000 and narrow emission line luminosities in both Type-2 AGN and H II galaxies.

4. By combining N2HA and narrow Hα line luminosity, we confirm a stronger negative correlation between Dn4000 and the parameter LR = 0.2 log L_Hα − 0.5 log N2HA in both Type-2 AGN and H II galaxies, with

smaller RMS scatters.

5. Using BPT diagrams, we find that LINERs show weaker dependence of Dn4000 on narrow emission line ratios and luminosities, indicating that LINERs have intrinsic physical properties distinct from Seyfert-2 galaxies.
6. The correlations between Dn4000 and LR are consistent for Type-2 AGN with different spectral S/N, redshifts, O3HB, N2HA, host galaxy morphology properties, and stellar velocity dispersions, leading to a robust and strong dependence of Dn4000 on the LR parameter in Type-2 AGN.
7. Applying narrow emission line properties to trace Dn4000 in Type-2 AGN provides a convenient method for estimating statistical properties of stellar ages in samples of more luminous AGN with weak host galaxy absorption features but prominent narrow emission lines.

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