Properties of Optical EMission-Lines

under varied Ionizing Conditions

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We explored the optical features of the nebulae created by white dwarfs and active galactic nuclei, the two most promising sources to create the nebula of LINER features, and studied the influences of varied physical parameters, including the ISM density and metallicity, effective temperature of white dwards, and ionization parameters, to the predicted line-ratios. We found that 1). the nebula created by the white dwarfs of high-enough effective temperatures and low-enough ionization parameter exhibits line-ratio features close to what we have observed in the circumnuclear region of M31; 2). The margin of the nebula created by AGN has line-ratio values in the LINER regime on the BPT diagram, but the AGN needs to be powerful enough to create the observed circumnuclear nebulae in the LINER galaxies; 3). The line-ratio values drops with increasing ISM metallicities, which could be explained by the drop of the nebula temperature as the consequence of increased cooling.

Introduction

A number of nuclei in local galaxies show optical emission lines characteristic of low-ionization nuclear emission-line regions (LINERs). Previous studies have found that the Active Galactic Nuclei (AGN) is the most possible ionization mechanism for circumnuclear LINERs. However, details in AGN-ionizing process remain to be explored. The circumnuclear region in M31 also shows LINER characteristic. But the lack of AGN activities in M31 makes the ionization source for M31 circumnuclear region a long-standing puzzle. Several other mechanisms can be invoked, among which the post-AGB stars are the most likely ionization sources.

Parameter Setting

ISM density	**10, 100, 10^3 cm^{-3}**
ISM metallicity	**$Z_\odot$, $2Z_\odot$, $3Z_\odot$**
Ionization Parameter	**-4—-1**
WD effective temperature	**0.5e5, 1.0e5 1.5e5 K**
Inner radius in the AGN case	**1e18, 1e19 cm**

marginal parameters/setting:

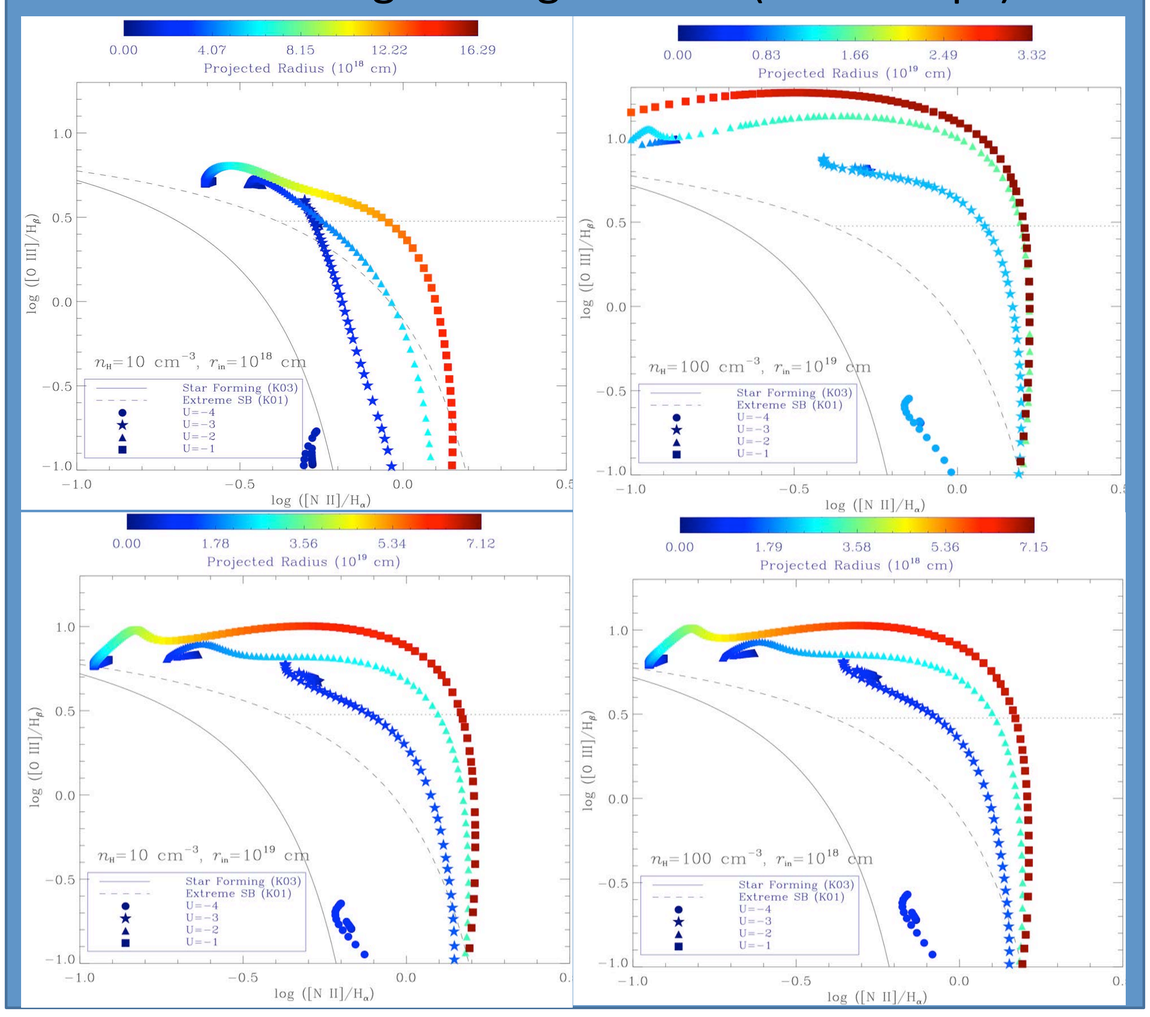
1). constant density (v.s. constant pressure);

2). open geometry for WD (v.s. closed geometry);

3). WD log(g)=6.0 (T_{eff}=1.5e5 K) or 5.0 (others);

AGN case

The outer region of the nebula has the LINER line-ratio feature, but a powerful AGN is needed (U=-1) to create the large enough nebula (R~1—10 pc).



WD Results

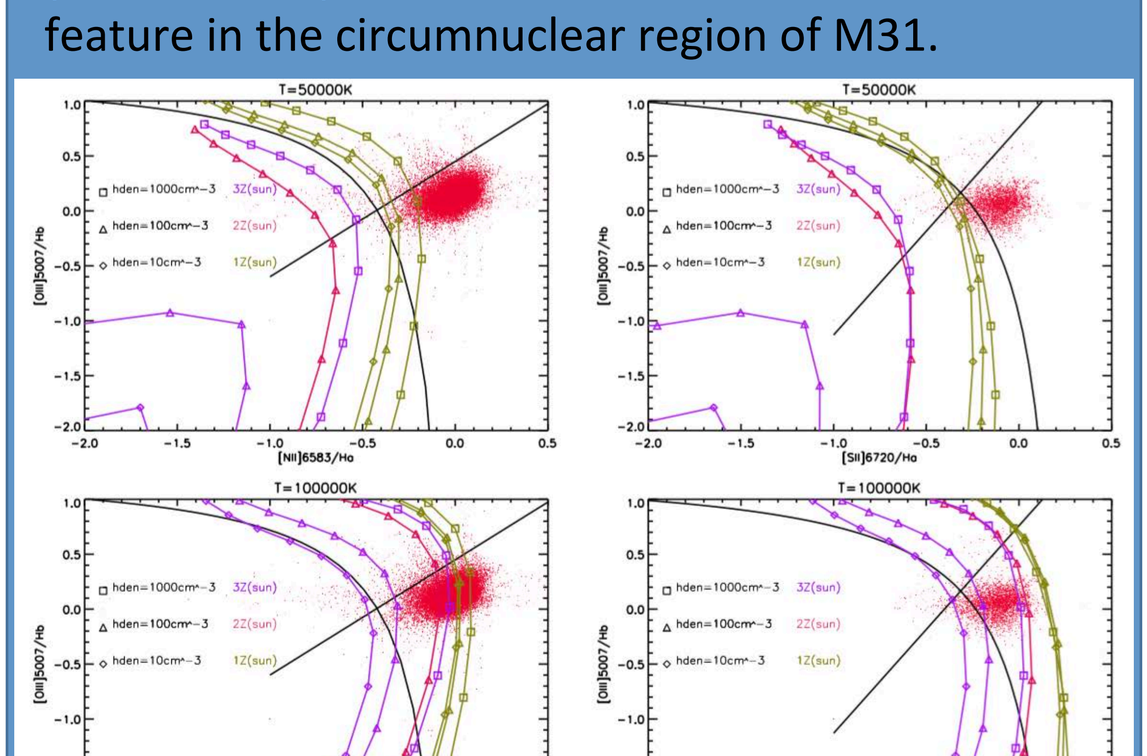
1. generally, lower [O III]/Hβ with U↓;
2. [N II]/Hα goes higher with U↓, but modestly smaller after U reaches ~$10^{-2.7}$;
3. higher line-ratio with T_{eff}↑;
4. higher line-ratio with n_H↑, but the difference becomes smaller with T_{eff}↑;
5. Lower line-ratio with Z_{ISM}↑,

   Explanation – higher cooling rate when Z_{ISM}↑;

   ➔nebula temperature↓

   ➔collisional excitation line ([O III], [N II])↓,

   but recombining line (Hα, Hβ)↑



Comparison with Observations

White dwarf of high-enough effective temperature (T_{eff}~1e5 K) and proper ionization parameter (U~10^{-4}—10^{-3}) could create the nebula of LINER feature in the circumnuclear region of M31.