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ORIGINAL ARTICLE

Stellar populations of classical and pseudo-bulges for a sample of isolated spiral galaxies

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Abstract In this paper we present the stellar population synthesis results for a sample of 75 bulges in isolated spiral Sb-Sc galaxies, using the spectroscopic data from the Sloan Digital Sky Survey and the STARLIGHT code. We find that both pseudo-bulges and classical bulges in our sample are predominantly composed of old stellar populations, with mean mass-weighted stellar age around 10 Gyr. While the stellar population of pseudo-bulges is, in general, younger than that of classical bulges, the difference is not significant, which indicates that it is hard to distinguish pseudo-bulges from classical bulges, at least for these isolated galaxies, only based on their stellar populations. Pseudo-bulges have star formation activities with relatively longer timescale than classical bulges, indicating that secular evolution is more important in this kind of systems. Our results also show that pseudo-bulges have a lower stellar velocity dispersion than their classical counterparts, which suggests that classical bulges are more dispersion-supported than pseudo-bulges.

Keywords Galaxies · Spiral-galaxies · Evolution-galaxies · Stellar content-galaxies · Bulges

1 Introduction

The properties of bulges, such as their structure, kinematics, and stellar population, are important to probe the physical mechanisms responsible for the formation and evolution of galaxies. Similarities between the global properties of many bulges and of elliptical galaxies have long been recognized (e.g. Kormendy 1985; Bender et al. 1992). However, recent observations have revealed that some bulges are more complicated than previously thought and may be formed from spiral disks (e.g. Fisher 2006). In the literature, bulges those appear very similar to pure elliptical systems are named as classical bulges and those relate to the disk are called as pseudo-bulges (e.g. Kormendy and Kennicutt 2004).

Classical bulges are typically having hot stellar dynamics and more nearly de Vaucauleurs $R^{1/4}$ surface brightness profiles (Kormendy and Kennicutt 2004). They have nearly the same fundamental plane relation as ellipticals (Bender et al. 1992, 1993). Pseudo-bulges are flat components with nearly exponential surface brightness profiles and thus more disk-like in both their morphology and shape (Fisher and Drory 2008a), and they are dominated by rotation in dynamics (Kormendy 1993; Kormendy and Kennicutt 2004). However, there remain many uncertainties in making a clear-cut distinction between these two cases, particularly in regard to the stellar populations of spiral bulges.

In the current paradigm, formation scenarios for bulges can be divided into two categories: one is identical to those for pure ellipticals and the other is to involve the secular evolution (see Kormendy and Kennicutt 2004 for a review). Classical bulges were formed through rapid and/or violent process which includes both the monolithic collapse of a primordial gas cloud (e.g. Larson 1974) and major/minor merging events (Kauffmann 1996). While in the secular evolution scenario, bulges have been slowly assembled by internal and environmental secular processes. Stellar population studies can potentially discern between different formation mechanisms responsible for spiral bulges. The detailed analysis of the stellar populations of nearby galaxies can be used

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