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Binary evolution and double sequences of blue stragglers in globular clusters

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Abstract. Binary evolution can produce different blue-straggler binaries, for example, blue stragglers with a bright, red component, or with a faint, blue component. In globular clusters, these blue-straggler binaries are generally observed as a single star, because two components can not be distinguished. Therefore, these blue-straggler binaries can be located in different regions of the color-magnitude diagram of globular clusters, e.g. blue sequence and red sequence observed in M30. We suggest that binary evolution can contribute to the blue stragglers in both of the sequences. Some blue stragglers in the blue sequence may have a faint white dwarf companion, while the red sequence includes some binaries experiencing mass transfer. It should be noted that the red sequence may also have other binaries, for example, the binaries just finished the mass transfer, and the binaries including a blue straggler (the accretors) that have evolved away from the blue sequence.

Keywords. binaries: general, blue stragglers, globular clusters, stars: evolution

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1. Introduction

Blue stragglers are brighter and bluer than the main-sequence turn-off stars in the color-magnitude diagram in globular clusters. They are found in almost all Galactic globular clusters (Piotto *et al.* 2004). Their location in the color-magnitude diagram suggests that they are more massive than other main-sequence stars. According to stellar evolution theory, these stars should have evolved away from their location and become a white dwarf, if they are normal single stars in globular clusters. Two popular mechanisms can explain the existence of blue stragglers in globular cluster, direct stellar collision (Hills & Day 1976) and binary evolution (McCrea 1964). Binary evolution may play an important role in open clusters and in the field. However, it is still debatable which is the dominant formation mechanism in globular clusters. Two blue-straggler sequences in the color-magnitude diagram (Ferraro *et al.* 2009, Dalessandro *et al.* 2013, Simunovic *et al.* 2014), as one of the most important observations of blue stragglers, may have significant information about the origin of blue stragglers in globular clusters.

2. Binary evolution and two blue-straggler sequences

It should be noted that mass transfer in binary systems can produce two kinds of blue-straggler binaries (as shown in Figure 1): (1) blue stragglers with a bright, red component; (2) blue stragglers with a faint, blue component. For the binary experiencing mass transfer, the accretor becomes a blue straggler while the donor is still a bright and

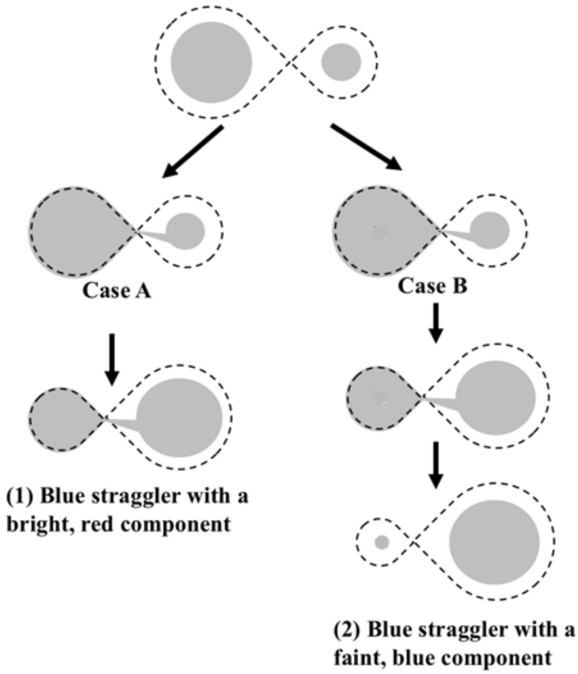

Figure 1. Path of different blue-straggler binaries from binary evolution.

red star. Therefore, they have a "low-luminosity boundary'' (about 0.75 mag brighter than the ZAMS) given by Tian *et al.* (2006), and can match the observed red sequence in globular cluster M30 (Ferraro *et al.* 2009; Xin *et al.* 2015).

However, the location of the other blue-straggler binaries may be very different. If the blue stragglers have a faint, blue component (e.g. faint white dwarf), they would have similar location of single blue stragglers (e.g. blue stragglers from binary merger or stellar collision) in the color-magnitude diagram. When these blue stragglers with faint components are considered, binary evolution can produce the blue sequence as well as the red sequence observed in M30. Furthermore, they would go through the red sequence twice, for example, before they evolve into the blue sequence or after they have evolved away from the blue sequence.

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