Contrib. Astron. Obs. Skalnaté Pleso **49**, 380 – 383, (2019)

Search for extrasolar planets around white dwarfs

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Received: November 28, 2018; Accepted: February 18, 2019

Abstract. We present a project aimed at detection of exoplanets orbiting around white dwarfs (WDs) using the method of transits. For our research we have selected some objects based on an indication of the presence of extrasolar giant planets around them. We have already started the long-term photometric observations using available telescopes in the northern hemisphere.

Key words: white dwarfs, extrasolar planets

1. Introduction

Presently, the search for extrasolar planets around other stars is at the top of astrophysical investigations. One of the most productive methods of search is the transit method that is based on photometric observations. The main requirement for a transit observation - the planet orbit plane is oriented nearly along the line of sight. Probability of such planet orbit orientation is proportional to the ratio of the planet radius to the star radius.

The simplest variant is to search for Jupiter-like planets on short period orbits. At the moment, the largest number of exoplanets was discovered around F-G stars with masses close to the solar mass. Majority of planets have their orbital periods from 1 to 100 days.

We present a project to search for planets near white dwarfs. This is very important because by the statistical presence or absence of planets in WDs, one can judge about the fate or evolution of planetary systems around near-solar-mass stars after the red giant stage. Besides, the small size of WDs and the very large width of the lines in the spectrum of WDs (a relatively flat spectrum without sharp lines) will provide an opportunity to identify the thin absorption lines of the atmospheres of the planets during eclipses.

2. The main idea of project

The main aim of the project is detection of exoplanets orbiting around WDs using the transit method. Nowadays there are about 20 thousand known WDs brighter than 19^m (Kleinman, S.J. et al., 2013). In the case if a WD has a transiting exoplanet we will definitely register significant brightness decrease of the central star. We can do it even if the eclipse is not total, since the sizes of a giant planet and a WD are comparable. Characteristic sizes of WD diameters have values close to the Earth diameter.
We consider the following arguments for the possible presence of planets in systems of WDs:
1. One of the first exoplanets was discovered in the system PSR B1620-26 "pulsar+WD"(Thorsett, S.E. et al., 1993).
2. Presence of planet remnants in systems of WDs (Farihi, J. et al., 2017).
3. Discovery of planets in two systems of subdwarfs V391 Pegasi and Kepler-70 (KOI-55) that experienced a stage of red giants (Silvotti, R. et al., 2007), (Charpinet, S. et al., 2011).
4. Discovery of disintegrating minor planets orbiting the WD1145+017 (Vanderburg, A. et al., 2015).

Advantages of extrasolar planet search around WD:
1. Prevalence of WDs (3%-10% from the number of all stars).
2. Easy to detect (a full or partial eclipse), which significantly reduces the requirements for the photometric precision.

Factors that complicate the extrasolar planet searching around WD:
1. Very low luminosity of WDs (absolute values are in the range 10^m - 15^m).
2. Quite small durations of eclipses (minutes).

Most of extrasolar planets have masses similar or greater than the Jovian mass and are at distances less than 0.5 AU from host stars. This fact increases the probability of finding extrasolar planets around WDs. According to our estimates, possible transit phenomena for close star-planet systems with WDs range from minutes to dozen of minutes.

3. Objects

For our research we used the data from the Sloan Digital Sky Survey DR7 White Dwarf Catalog, containing 20 thousand WDs. We collected information on magnitudes of the WDs obtained in the filters u, g, r, i, z, and calculated u-g, *g-r*, *g-i*, and *g-z* values. Fig. 1 shows that some WDs are far from the main group of objects. In our opinion such excess value may be due to the fact that during the object observation with one of the filters the WD was eclipsed, possibly, by an exoplanet.

From noted WDs we have selected several objects that are visible in the northern latitudes: SDSS J070546.78+393453.4, SDSS J220823.66-011534.0, SDSS J131156.70+544455.8, SDSS J085612.42+143756.9.

We have already started the long-term photometric observations using the telescopes of MAO NAS of Ukraine, the Terskol observatory of Northern Caucasus, the telescopes of the AI SAS and Slovak Central Observatory. However, it is necessary to carry out many new observations and analyze the periodograms obtained from light curves to receive reliable results.

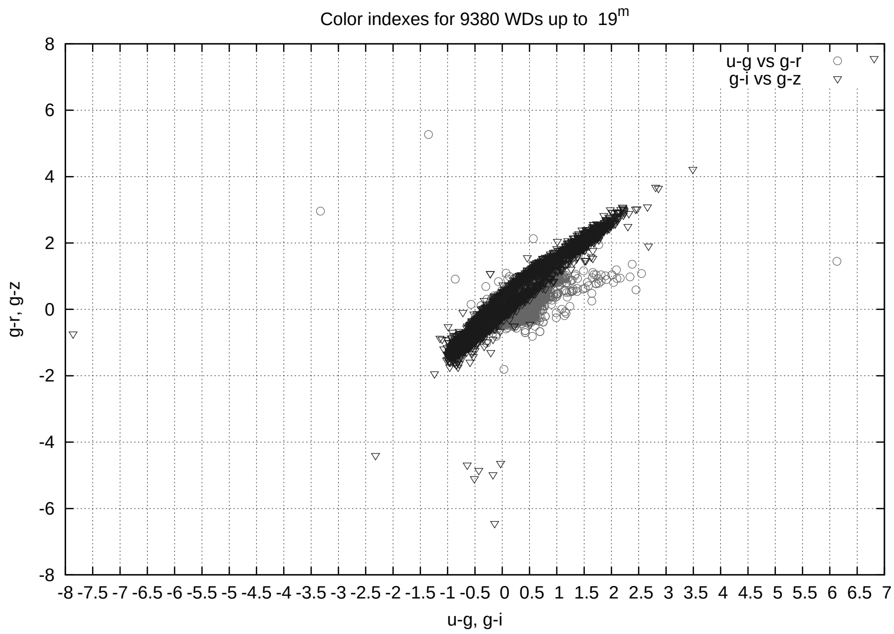

Figure 1. Distribution of white dwarfs by the color index.

4. Conclusions

The development of this method and its testing will allow us to discover new exoplanets, or estimate the limits of distribution probability of giant planets in systems of WDs. Observational data obtained using meter-class telescopes fully satisfy the requirements of the task. In the near future we also plan to use the data from astronomical catalogues.

We welcome everyone who is interested in this problem and wants to join our team for work on this project.

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