Temperature and cooling age of the white dwarf companion of PSR J0218+4232

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We report on Keck optical BVRI images and spectroscopy of the companion of the binary millisecond pulsar PSR J0218+4232. A faint bluish ($V = 24.2, B - V = 0.25$) counterpart is observed at the pulsar location. Spectra of this counterpart reveal Balmer lines which confirm that the companion is a Helium–core white dwarf. We find that the white dwarf has a temperature of $T_{\text{eff}} = 8060 \pm 150$ K. Unfortunately, the spectra are of insufficient quality to put a strong constraint on the surface gravity, although the best fit is for low $\log g$ and hence low mass ($\sim 0.2 M_\odot$), as expected. We compare predicted white dwarf cooling ages with the characteristic age of the pulsar and find similar values for white dwarf masses of 0.19 to 0.3 $M_\odot$. These masses would imply a distance of 2.5 to 4 kpc to the system. The spectroscopic observations also enable us to estimate the mass ratio between the white dwarf and the pulsar. We find $q = 7.5 \pm 2.4$, which is consistent with the current knowledge of white dwarf companions to millisecond pulsars.

Pulsars: individual (PSR J0218+4232) – stars: neutron stars – stars: white dwarfs

Introduction Millisecond or recycled pulsars are almost always found in binaries. Their short (millisecond) periods are believed to be caused by the accretion of matter from the binary companion, which spins up the neutron star, and, by means poorly understood, decreases its magnetic field. This accretion will happen when the companion, in the course of its evolution, overfills its Roche lobe.

When the companion of the pulsar is a white dwarf, one would expect the cooling age of the white dwarf to match the age of the pulsar. This because the cooling and spin-down clocks start ticking at roughly the same time, when the companion starts to contract to a white dwarf and the pulsar turns on following the cessation of mass transfer.

The age of a spin-down powered pulsar, with period $P$ and period derivative $\dot{P}$, is given by equation

$$\tau_{\text{PSR}} = P(n - 1)\dot{P} \left[1 - (P_0P)^{(n-1)}\right],$$

where $P_0$ is the initial period.