Asteroseismology of Pulsating White Dwarfs

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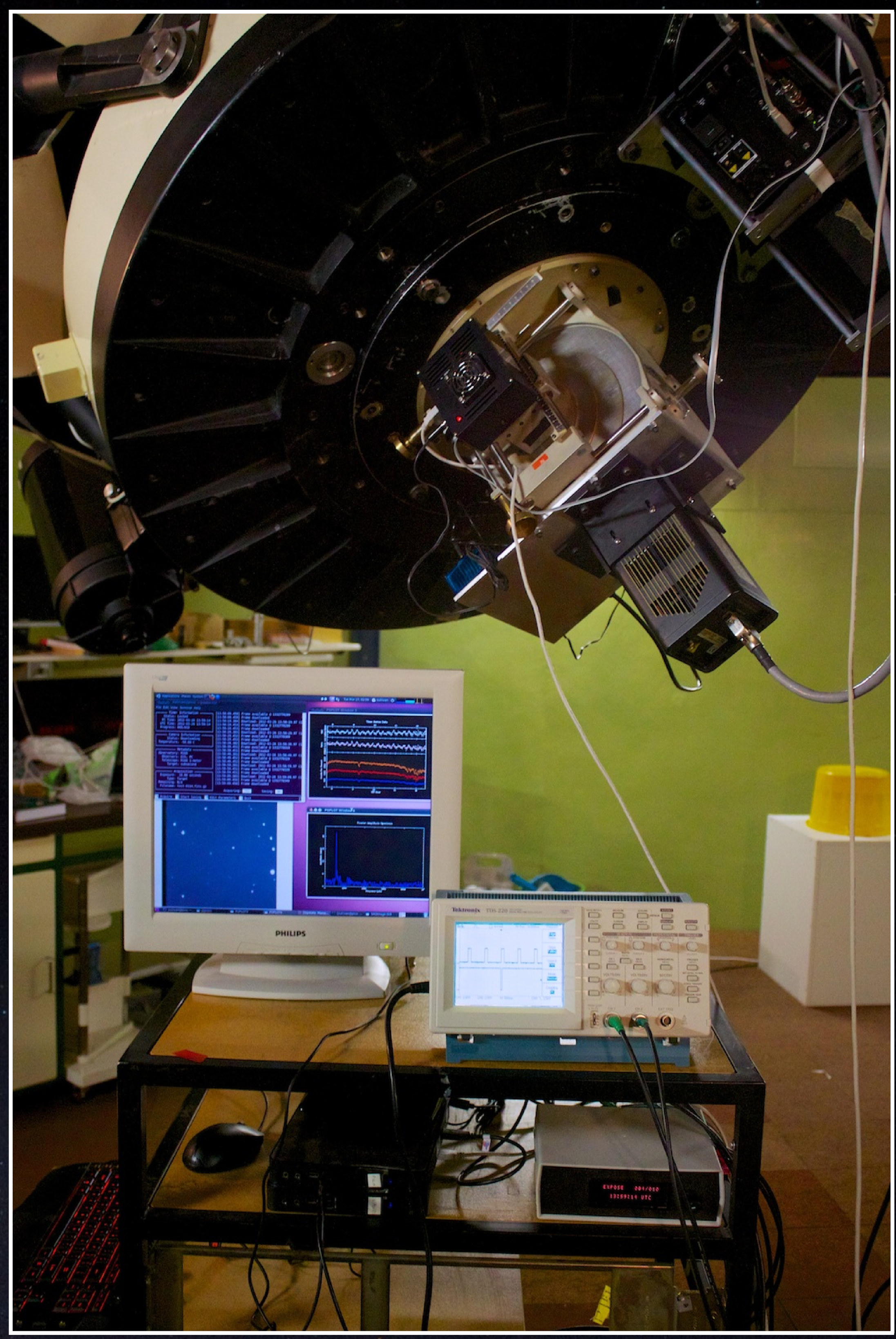
After the core nuclear reactions in a star have exhausted most of the hydrogen and helium fuel it will evolve into one of three final states depending on its mass: a white dwarf, neutron star or black hole. The vast majority of stars (over 97%) are predicted to end their lives as white dwarfs.

White dwarfs have a mass comparable to the Sun compacted into a sphere about the size of the Earth. Structurally they have an extremely dense core, which consists of a classical gas of carbon and oxygen nuclides and a separate quantum gas of electrons; this is overlaid by a thin atmosphere similar in thickness to that of the Earth, containing hydrogen and/or helium.
The majority of white dwarfs appear bluer than most other stars as their surfaces are relatively hot, but they are intrinsically faint due to their small size.

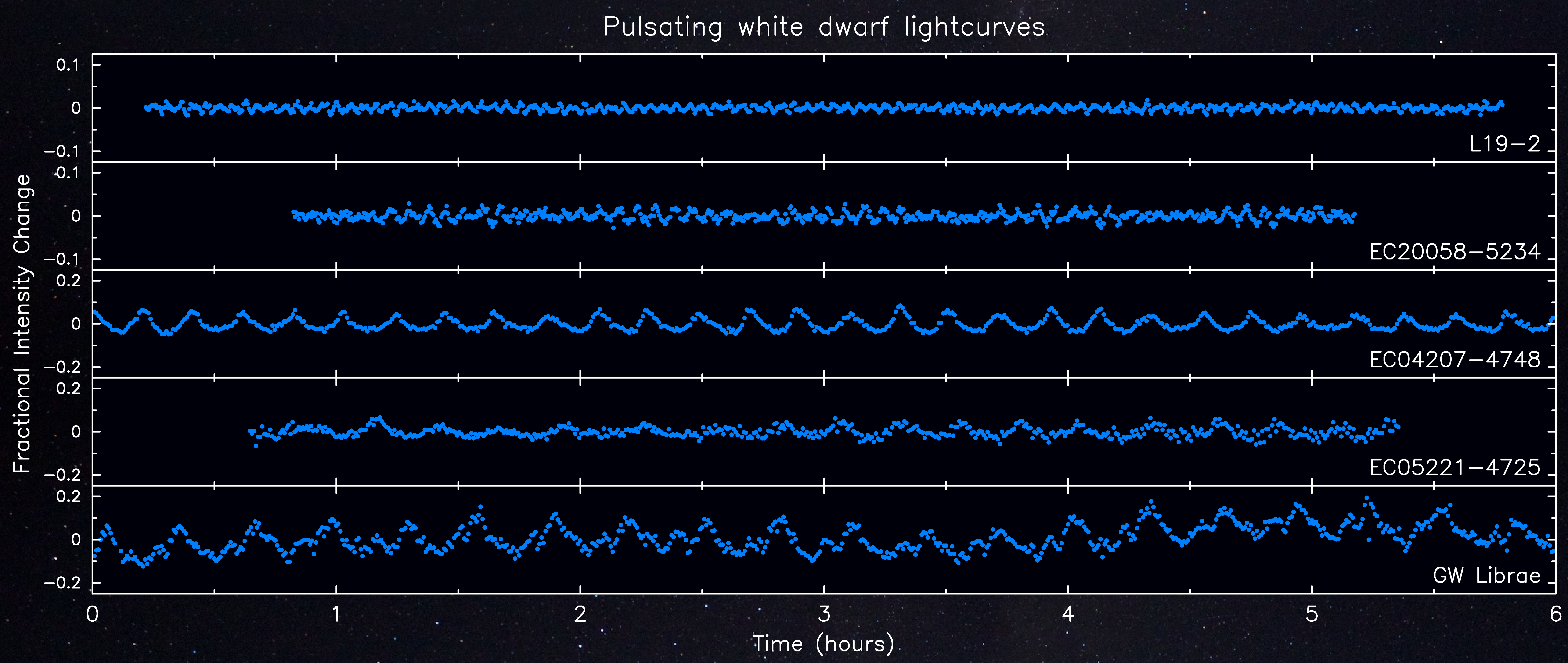
Size comparison of our Sun, Jupiter, and a typical White Dwarf

A white dwarf will cool slowly over time as its internal energy radiates away. When its surface temperature passes through a particular regime (about 25,000 Kelvin for those with helium atmospheres and about 12,500 Kelvin for the hydrogen atmosphere variety) the energy passing through the atmosphere can interact with the hydrogen or helium to drive complicated "nonradial" pulsations. These pulsations manifest at the surface as periodic temperature variations, which change the apparent brightness of the star on timescales of a few minutes.

We can study the internal structure of the star by analysing these brightness variations in a manner that is similar to how seismologists use earthquake data to study the Earth's interior. This makes them a unique laboratory for studying exotic physics at high temperatures and densities.



Our photometer mounted on the 1-metre telescope at Mt John University Observatory, Lake Tekapo, NZ. The 1-metre dome is shown in the poster background.



By integrating a commercial CCD camera and GPS receiver with custom electronics and computer software, we have created a flexible instrumentation system (a photometer) for capturing the brightness variations of faint stars. Our hardware design and control software are open source - visit `http://pchote.github.com/Puoko-nui/` (or scan the QR code) for more information.

We regularly use our instrument to study pulsating white dwarfs using the 1 meter telescope at Mt John University Observatory (MJUO) at Lake Tekapo, NZ. A second instrument is operated by the University of Texas (Austin) in the USA, where they also observe white dwarfs, as well as other objects.

The plot above shows the brightness variations of five pulsating white dwarfs we have been studying. The brightest of these stars (L19-2) is about 800,000 times fainter than the brightest star in the sky. The faintest (GW Librae) is about 20,000,000 times fainter.

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