The Music of the Stars

Studying the Structure of Stars Using Asteroseismology

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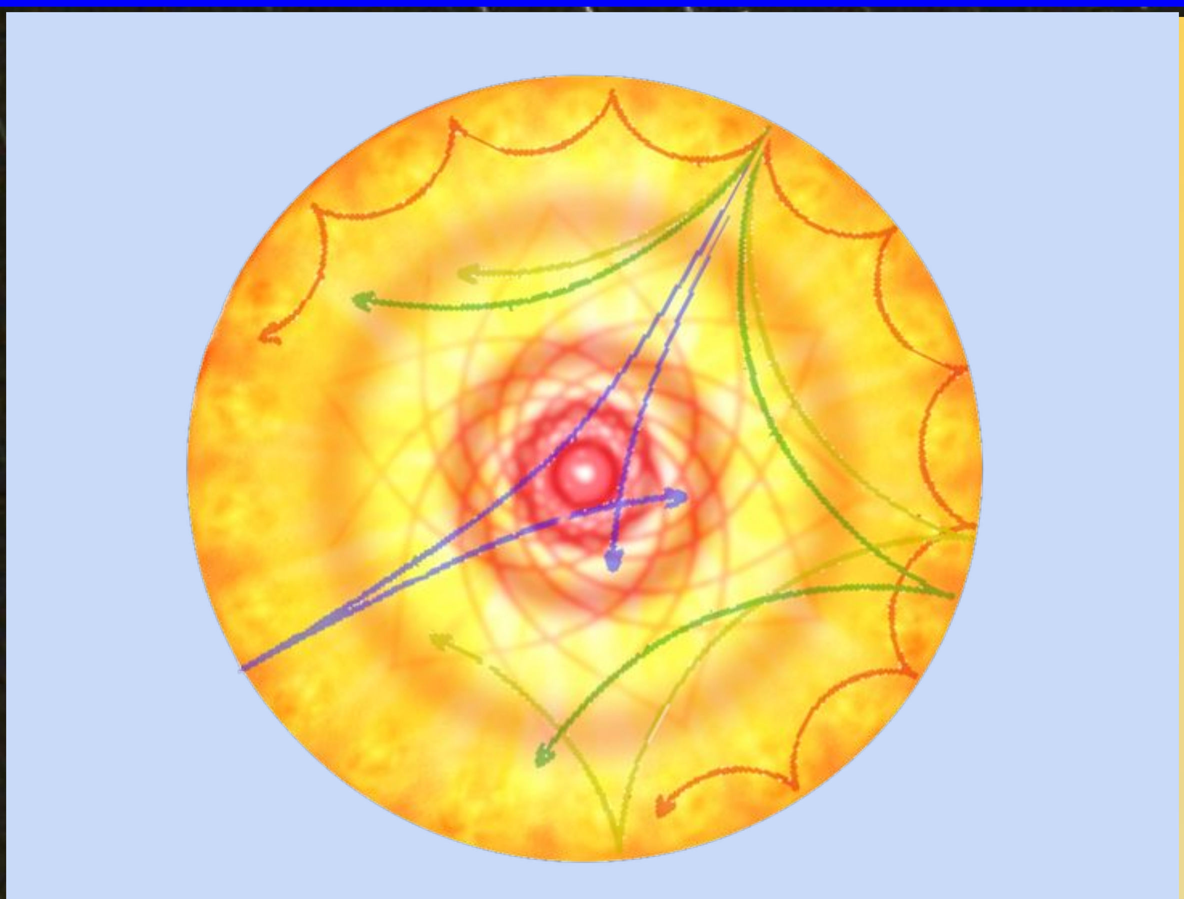

Figure 1: A slice of a stellar interior, showing how pulsations (blue and red lines) samples different regions of a star.

Fig. 3: 40 Eri B is a nearby white dwarf. This image shows a comparison between the volume of the Earth and 40 Eri B. Despite their similar volumes, 40 Eri B contains half of the mass of the sun!

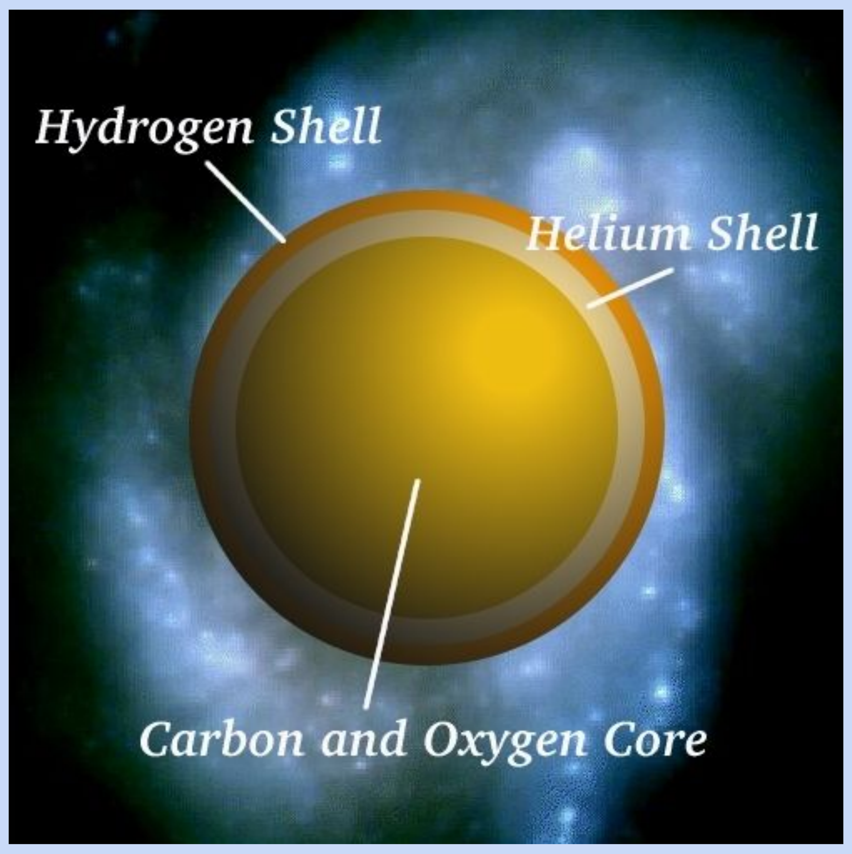

Fig. 6: The general structure of a white dwarf star. We use the information in Fig. 5 to determine stellar mass, the interior structure and how deep each layer is, how massive the core is, the exact composition of the core, ad the rotation properties of the star.

Asteroseismology is the study of stellar structure by observing stellar pulsations. Every star, including our Sun, pulsates. Many stars pulsate with multiple frequencies. Each pulsation samples a different region of the stellar interior (Fig. 1). As the star pulsates, its overall brightness changes with time (Fig. 2). We observe these brightness changes on Earth. Using this information, we can build a model of the stellar interior. A good analogy is to think about a bell. A bell rings with a tone that depends on its structure and composition. Stars do the same thing. How stars pulsate depend on their interior structure. Why is this important? Well, all of the photons we observe from any star come from the star's surface. We can't learn anything about the inside of the star from those photons. We can only "look" inside a star by studying its pulsations.

At Mt. Cuba Observatory, we specialize in the study of pulsating white dwarf stars (Fig. 3). White dwarfs are stars that have exhausted their nuclear fuel and populate the stellar graveyard. Our Sun will become a white dwarf in about 4 billion years. We learn about processes in our Sun and other stars and about the Milky Way's history by studying white dwarfs.

We use a technique called differential aperture photometry to measure stellar brightness (Fig. 4). We compare the variable star to nearby stars that are hopefully steady in brightness and create a light curve such as in Fig. 2.

Once we have the light curve, we want to know the periods the star pulsates at (Fig. 5). We do this using a tool called a Fourier transform. This tool breaks down a function into its component sine waves. The distribution of pulsation periods gives us information about the stellar interior. We can learn about the star's mass, internal layer structure, rotation properties, and magnetic fields (Fig. 6). For more info, go to mountcuba.org.

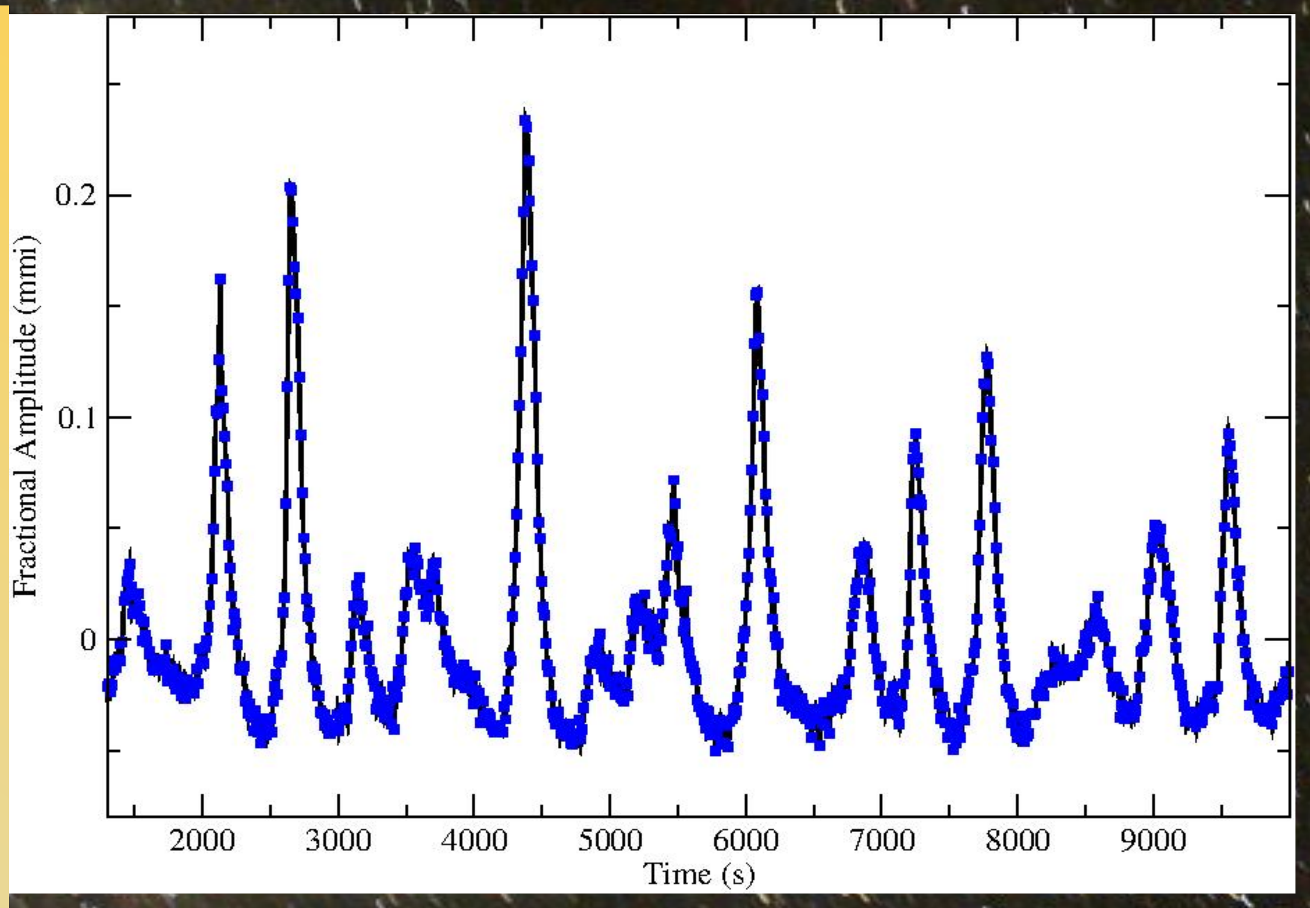

Fig 2: A light curve of the pulsating white dwarf GD358. The x axis is time, and the y axis is brightness.

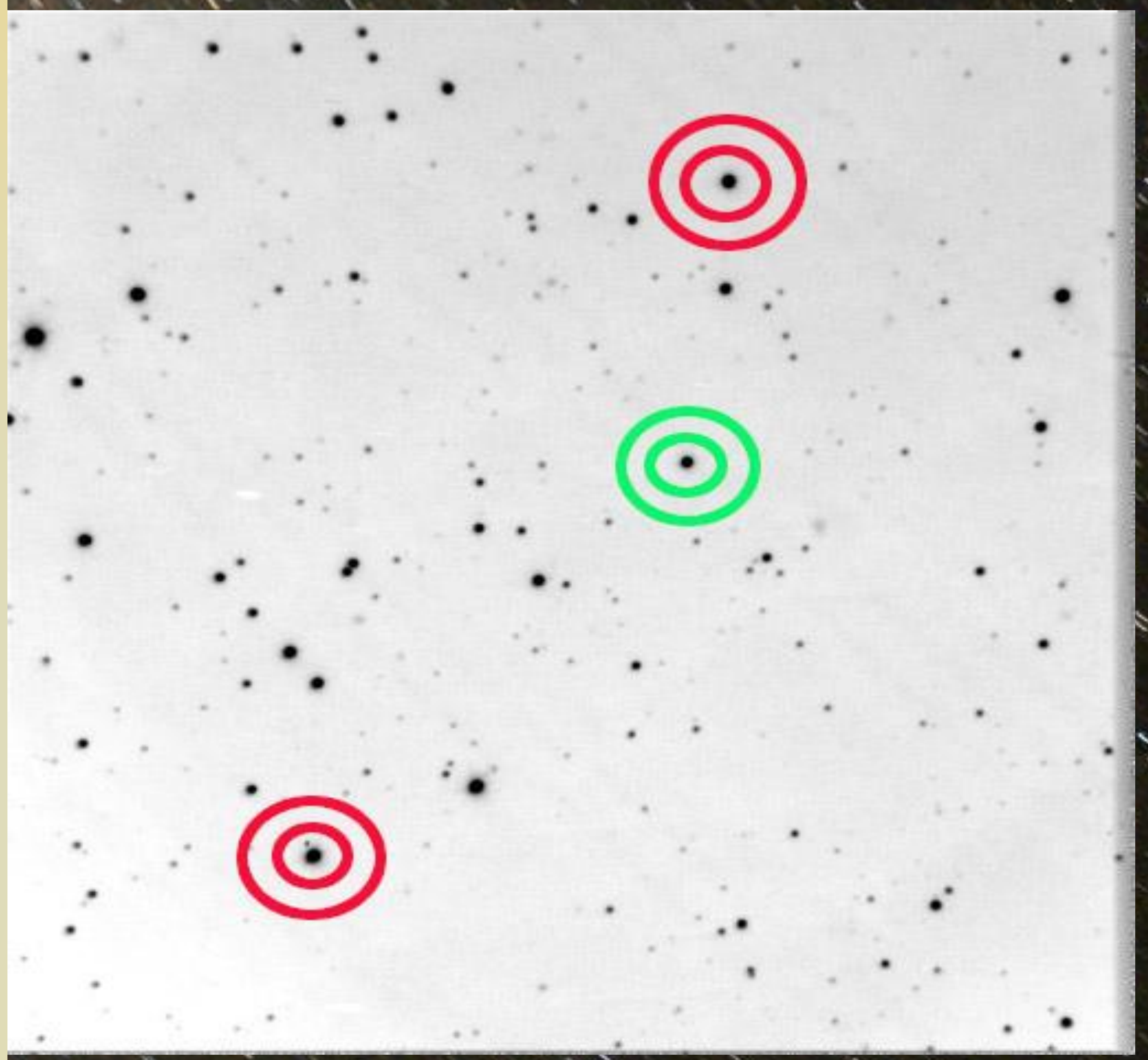

FIg 4: Aperture photometry of the white dwarf GD358. We count the photons from GD358 in the center of the green circles and measure the sky contribution using the ring between the green circles. Comparison stars are in red. Measurements from many images gives the light curve in Fig 2. Colors are inverted and so stars appear black.

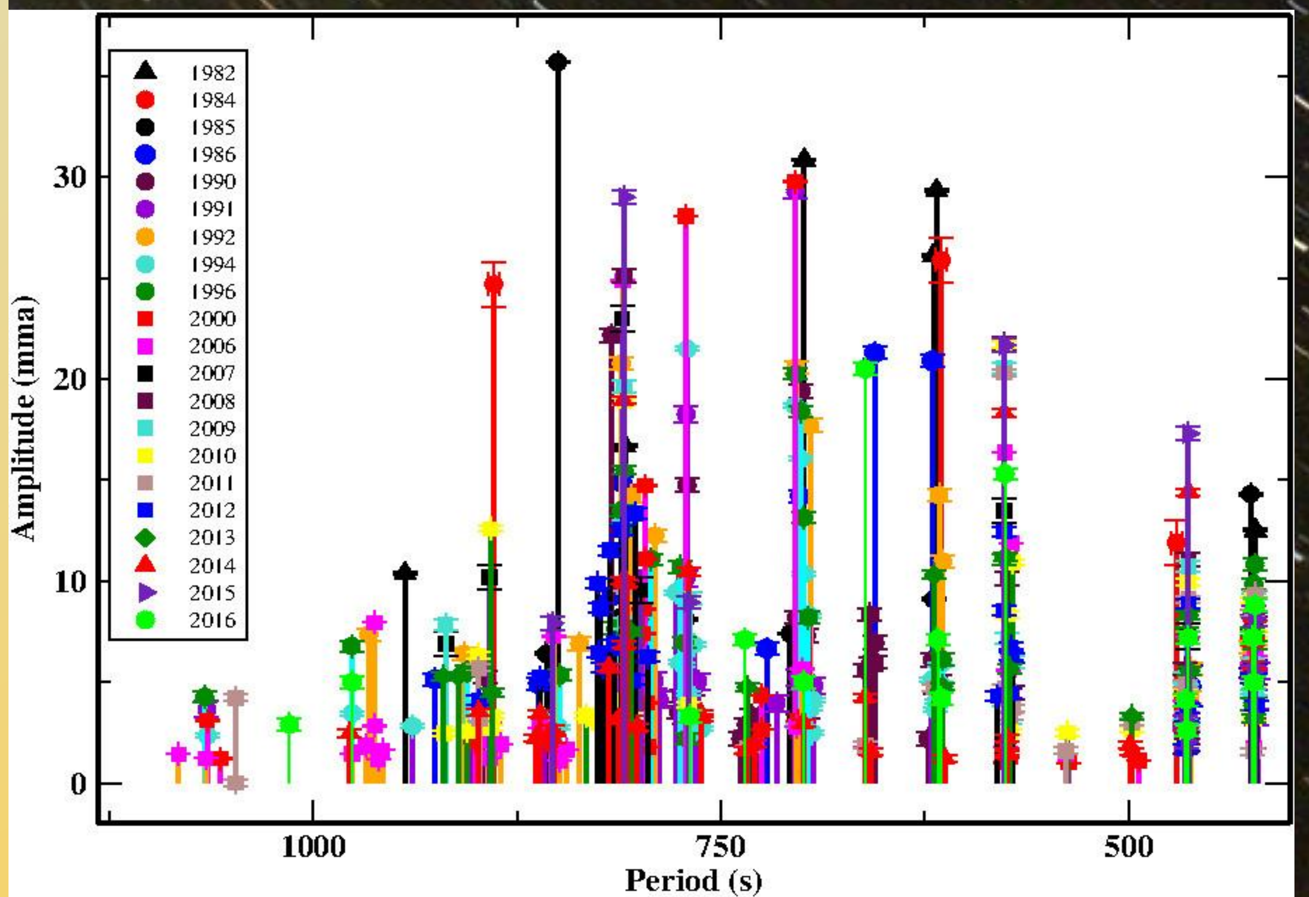

Fig. 5: The pulsation frequencies of the white dwarf GD358. This distribution is not random, and gives us information about the interior structure of the star.