BRIEF

VARIABLE STARS
Variable Stars Overview

Overview

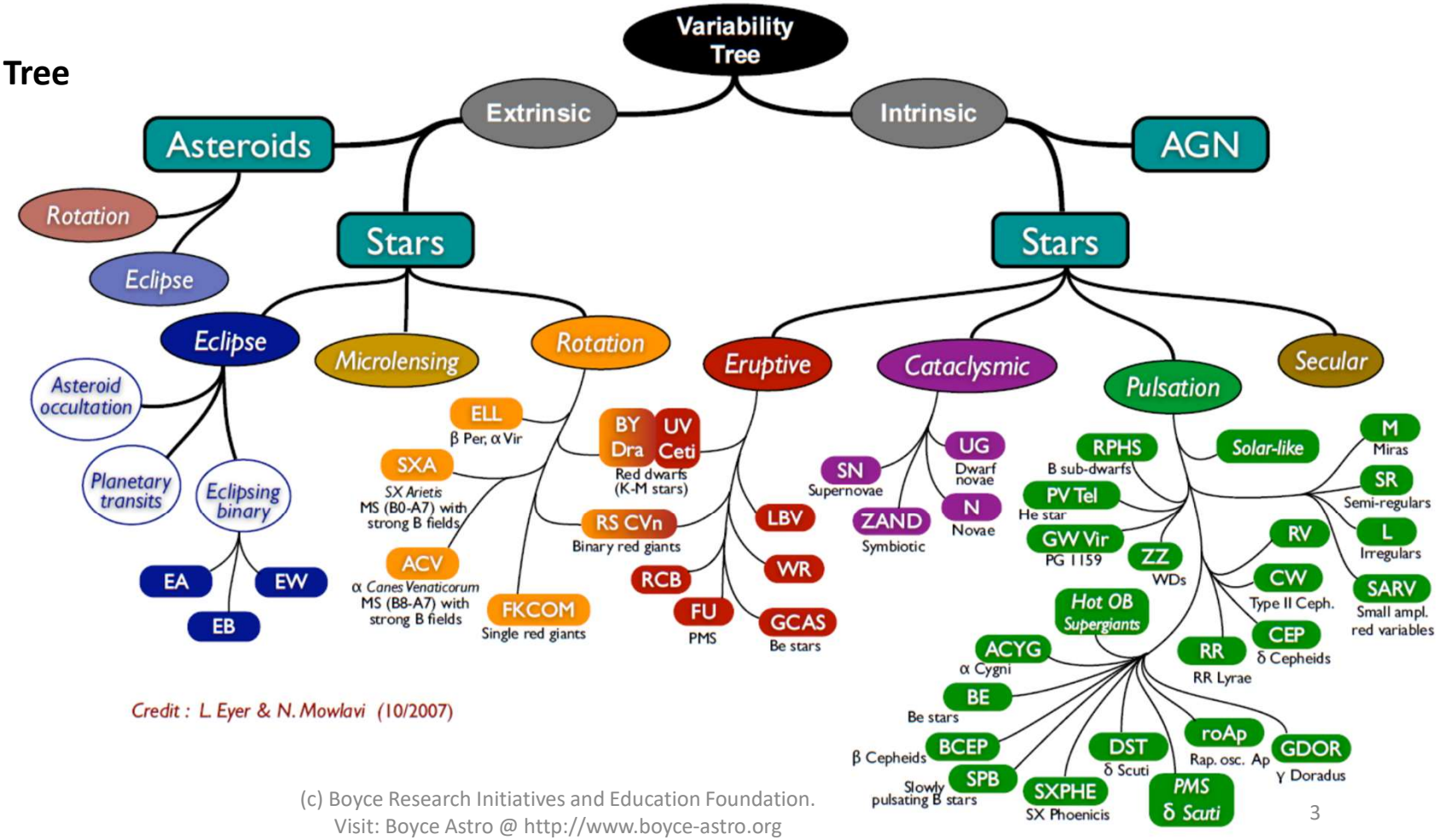
The night sky, with its familiar patterns of stars cross our skies year after year, appears perfect, steady, peaceful, serene, and unchanging. However, the reality of the stars in our Universe are much different than this idealistic view.

Stars are a giant balls of gas in a delicate balancing act between the force of gravity trying to crush all the mass and the force of nuclear burning at the core of the star trying to blow it apart.

Throughout its life, there are sometimes battles fought between these two forces that ebb and flow, swelling and shrinking the star. This causes their light to vary.

Others light varies, not because of internal struggles, but of exterior interactions. Together, these two types of interactions create a group of stars known as Variable Stars. Every star has been and will be variable in its light output at one time or another. It is inevitable. If you could just live long enough you'd see every star is a variable star.

The Variability Tree



Credit : L. Eyer & N. Mowlavi (10/2007)

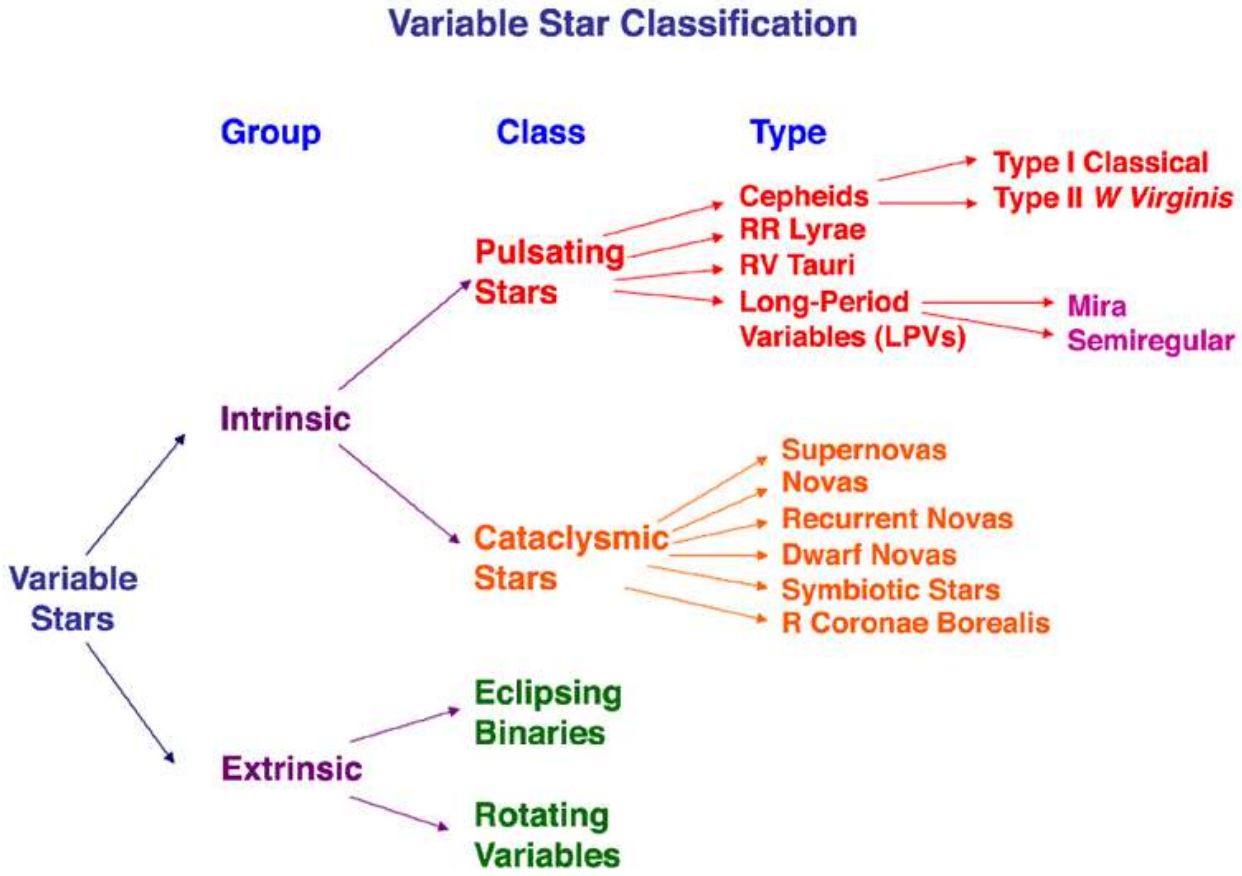
Groups & Classes of Variable Stars

Groups:

- Intrinsic: Due to internal factors
- Extrinsic: Due to external factors

Classes:

- Pulsating: Internal Processes
- Cataclysmic: Violent Outbursts
- Eclipsing: Close Binary Star Systems
- Rotating: Star Spots & Close Systems



Extrinsic Variables

Stars where the variability is caused by external properties like rotation or eclipses. Different from Intrinsic whereas the total energy output of the star is not varying, yet the amount of light we see from our vantage point on Earth varies.

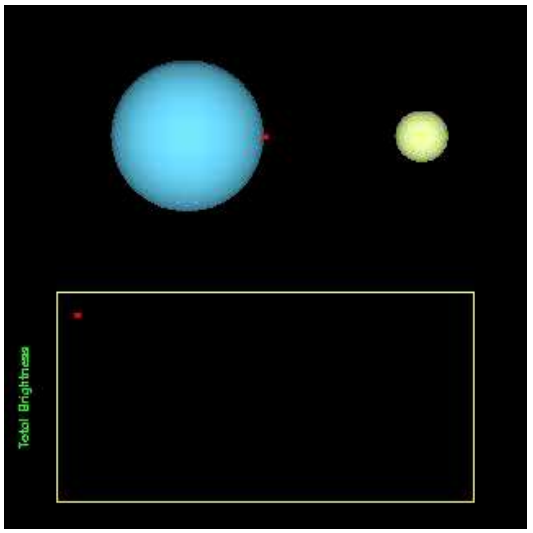
Eclipsing variables: Orbital plane of the star and its companion coincides with our line of sight to the system. As one component passes in front of the other, we see a dip in the light output.

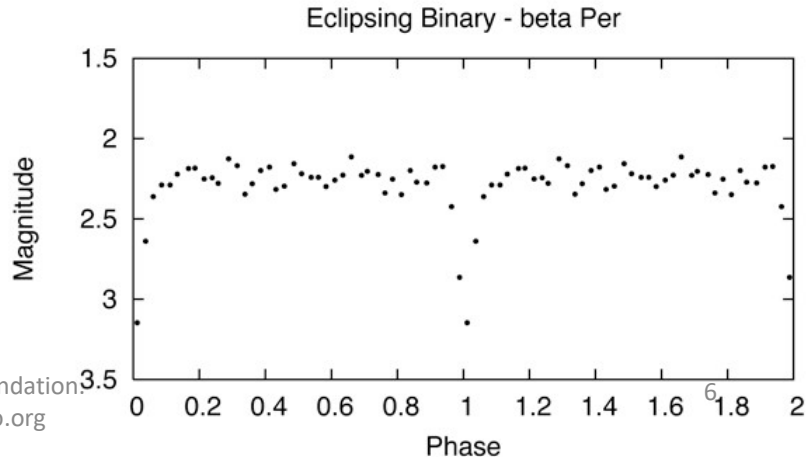
Rotating variables: Main causes may be star spots rotating in and out of view, pairs of stars so close that they are tidally locked where one star is super-heating the portion of the other star facing it, or stars orbiting each other so close the components are stretched by gravity into non-spherical shapes.

Microlensing variables: Variations brighten, and fade, when an object acting as a gravitational lens passes in front of the star from our point of view, magnifying the light from the more distant object.

Eclipsing

- Binary star systems where the orbital plane is aligned with the direction toward the sun and the solar system
- During their orbit they can undergo mutual eclipses as one component passes directly in front of its companion
- During the eclipse events, the observed brightness will decrease
- Eclipsing systems apparent magnitudes tend to remain relatively constant until an eclipse occurs.





Intrinsic Variables

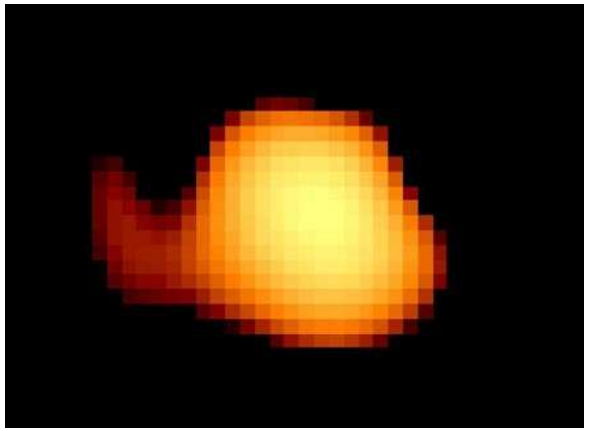
Intrinsic variable stars are stars that vary their luminosity output due to physical changes within the star itself.

These are subdivided into Pulsating and Cataclysmic. The difference is that pulsating covers stars with variability internal to its photosphere and cataclysmic covers things that explode or blow up.

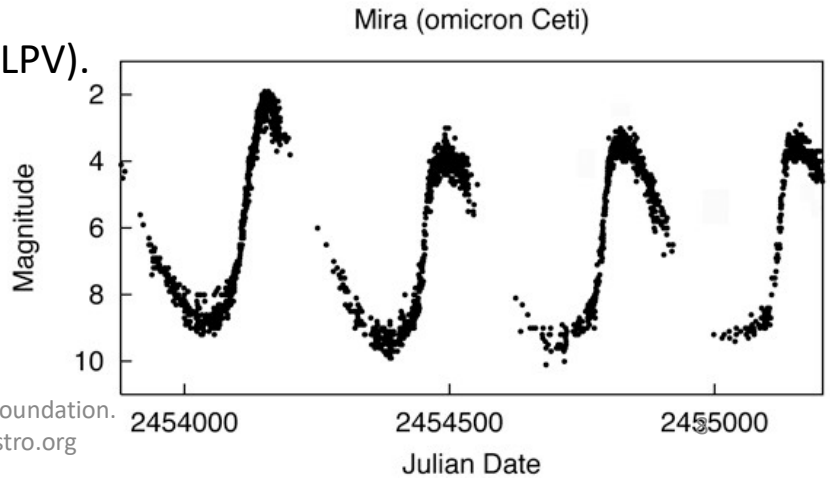
- Pulsating variables
  - Expand and shrink dramatically within a short period of time in particular patterns. In some cases, Cepheids, these variations can outline true characteristics such as luminosity. RR Lyrae stars are similar.
  - RV Tauri stars, supergiants with greater light variations, are in the later phase of life where internal fusion is struggling to keep up with gravity.

- Cataclysmic variables
  - Change luminosity due to rapid or violent outbursts caused by thermonuclear processes either on the surface or deep inside.
  - Examples are Supernovae, Novae, Recurrent Novae and Dwarf Novae are a group of stars that have dramatic or sudden magnitude increases, usually because of a stellar explosion.

Pulsating

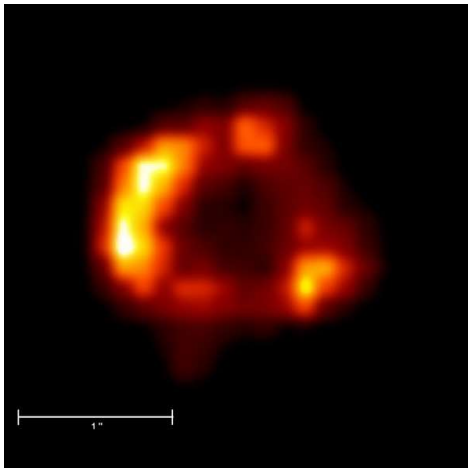


- There are many different types of pulsating variable stars. Some of them vary in brightness by as much as 100 times, and some have cycles that repeat as often as every few days, while others vary over months or years.
- Typically, these stars pulsate because they are at the end of their lives and have become unstable.
- Study is important for internal structure and process of evolving stars
- Most famous type: Cepheid Variables
- One sub-type of pulsating variable is a Long Period Variable (LPV).

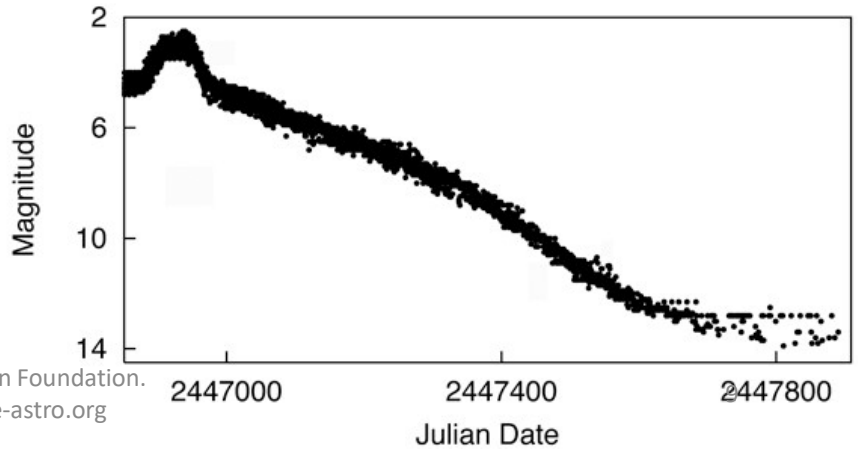


Cataclysmic/Eruptive Variables

- These stars are more likely to have very irregular cycles.
- Protostars, which in the process of becoming main sequence stars, often have variations in their brightness.
- Giants and supergiants lose their matter relatively easily and may also experience eruptions.
- White dwarfs that are part of a binary system may also experience eruptions as they take matter from their companion star.
- Most extreme case of an eruptive variable is the supernova.

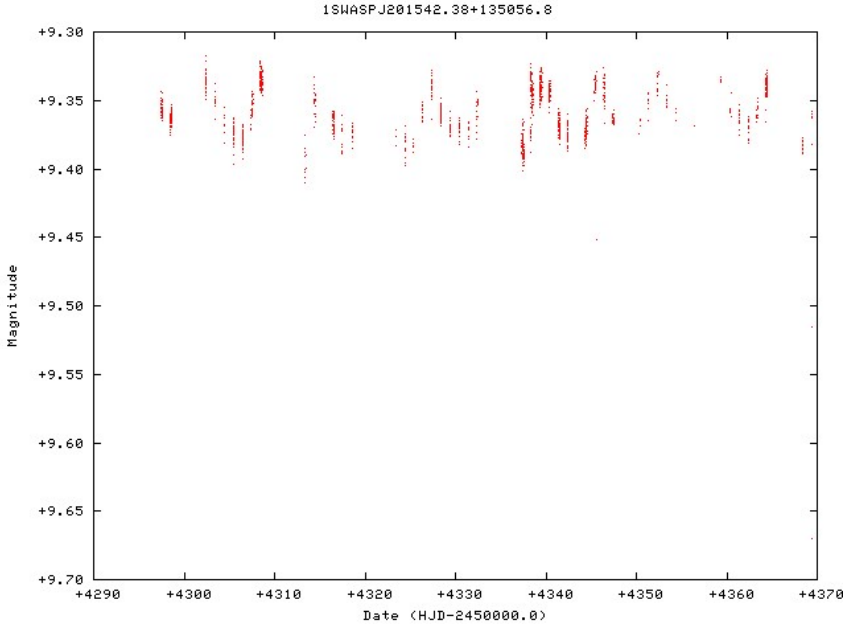


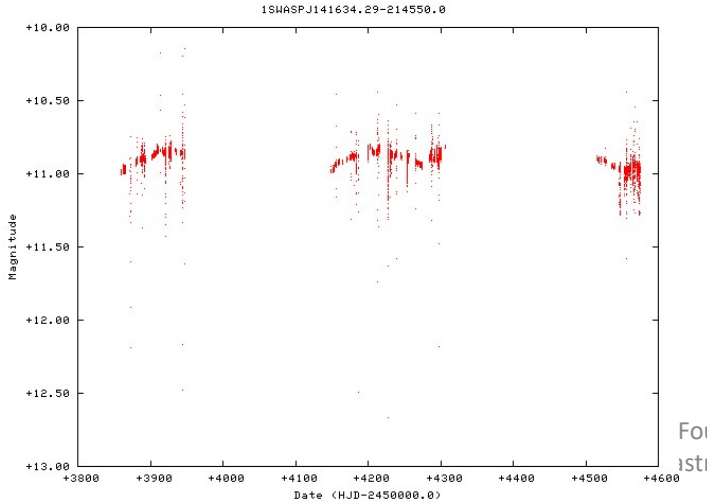
Supernova - SN 1987A



Rotating

- Vary due to non-uniform surface and/or ellipsoidal shapes
- Due to “sun” spots or other physical changes.
- Magnetic fields vary with the variability in brightness
- Other rotating variables are stars in close binary systems with ellipsoidal components
- Rotating variables do not eclipse each other, from our perspective





Summary

Variable stars are wide and diverse.

What they have in common is a varying light output as seen from our vantage point.

As we will see in future lessons, these cover all parts of the HR Diagram. As such, the study of these helps to further our understanding of varying parts of stellar life and to refine existing stellar theories.

Questions?