Intro for the star β cep with what is known, the type of variable star etc. Important to give reference to past papers on Β Cep.

β Cephei:

According to the American Association of Variable Star Observers [1] β Cephei stars are classified as variable stars having spectral types of B0-B2 III-V and corresponding surface temperatures between 20 and 30,000 Kelvin. They are near the top of the main sequence on the H-R diagram. Their periods were found to range between 0.1 and 0.3 days (not accounting for slow rotators), and they have quite large radial velocity amplitudes. Based on satellite observations in the UV range, the variability is easily measured; however changes in colour in the blue and visual spectral regions are difficult to measure [2] as their variations are minute. Differentiating them from RR Lyrae stars and classical Cepheid stars, the light curve of β Cephei stars have a lagging period of approximately 90 degrees. This means the maximum brightness observed occurs at the minimal radius (during contraction), and the minimum brightness occurs when the star expands, so both the luminosity and the colour show that the maximum temperature occurs coincidentally with the minimum radius [2]. Particular to β Cephei stars are also pulsation periods which are nearly equal, producing the beat phenomenon, characterized by slow and regular rises and falls in the amplitude of variation. The beat phenomenon may occur due to tidal distortions caused by binary companions, as some observed binaries seem to have some natural periods with some slight difference [3].

The analysis of stellar interior structure allows for the study of stellar evolution with the uncertainties comprising of the angular momentum evolution, internal mixing, lifetime on the main sequence, and opacities of stars. Asteroseismology allows for these questions to be addressed by observing the pulsations of a star. Spectroscopic and photometric results from β Cephei stars were utilized by Handler et al. (2004) [4] to determine the convective core size and the metallicity of ν Eridani, which showed an increase of the rotation rate closer to the core. According to the results of their publication, frequency analysis of ν Eridani’s pulsations revealed p and g mode variations as well as high-order gravity-mode pulsation. Modes excited by the Kappa mechanism that may cause the oscillations in low-order gravity modes with periods that span several hours are intrinsic to slowly-pulsating B and β Cephei variables, which ν Eridani may also classify as.

\* for periods and pulsation mechanisms reference article 🡪 <https://www.aanda.org/articles/aa/pdf/2009/40/aa12025-09.pdf>

Due to the periodic changes in luminosity, a change in radius and surface temperature is also inferred according to the luminosity relation, L = 4. The instability mechanism responsible for the pulsations of β Cepheid stars has been the subject of much debate and endured a number of hypotheses before the opacity of hydrogen and helium were put into consideration. As Cepheids are giants or supergiants, their structure consists of a small, dense core and a large envelope with a much lower density, so the contraction and expansion in the radius of the star causes the surface temperature to vary proportionally to the change in radius. Radial compression in a Cepheid causes the production of doubly-ionized light absorbing helium nuclei (an opaque layer) in the star’s envelope [5]. As photons become absorbed, the star heats up and the high-pressure gas causes expansion, and the cooler outer layer regains a composition of singly-ionized helium that is more transparent. Photons are permitted to escape, causing a period of greater luminosity, causing the gas to cool down again and the pressure to drop, and the Cepheid begins to compress due to gravity.

Particular to β Cephei variables, the kappa mechanism describes the modulation of radiative luminosity. Kappa mechanism works relatively similar to the process described above: compression causes an increase in temperature and the quantity of double-ionized helium and therefore opacity, radiation is trapped and gas is heated, pressure increases and the star expands, radiation escapes, and so on. β Cephei stars are hotter than classic Cepheids, which places them towards the left of the H-R diagram, on the instability strip; they are surmised to contain hydrogen and helium which is already ionized. Cephei stars have a dependence on iron in the composition of its gases; results from the Optical Gravitational Lensing Experiment’s survey data revealed from photometric analysis some 75,000 early B-type stars, with 64 most likely being β Cephei stars in the Large and Small Magellanic Clouds, which have low metal abundances [6]. The abundance of iron at some depth within the star at higher temperatures will have an increased opacity, and hence an increase in the buildup of potential energy that acts as an outward force. This results in the changes of radius observed and the repeats the pulsation cycle in the matter of mere hours. This process is also referred to as the Fe bump as the change in iron opacity drives the cycle to repeat by expanding the outer layer [7].

[1] [https://www.aavso.org/vsots\_βcep](https://www.aavso.org/vsots_betacep)

[2] [http://articles.adsabs.harvard.edu//full/1978ARA%26A..16..215L/0000216.000.html](http://articles.adsabs.harvard.edu/full/1978ARA%26A..16..215L/0000216.000.html)

[3] <http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1967JRASC..61..117P&defaultprint=YES&filetype=.pdf>

[4] <https://watermark.silverchair.com/347-2-454.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAmwwggJoBgkqhkiG9w0BBwagggJZMIICVQIBADCCAk4GCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMlSv56LNobE9tLKpXAgEQgIICH4yJMsmbFMuDK4If_nOYA0JQRred1ndV3bHA2YpQ2STMwnScOT1kOiuX9XAnkdKkHOuY4ZY4IIWlBQiBc4tFeAnYoDq1aRcIAW8nY39wCiXp_Z5veOlyYXlpKs5OkvOuop9rFkam5QsArP6dOhkn3-QXQjPOA_RN69UDsgE3S2uOOc7fZDKPDvyzc_drfL2TDQ7TOidMJiYNVtLOPcSaHN0qMVJ7v0U1F2d32ISYd6dBMuwDDAnA0O6T8QpTf1w_FeMvOgc4izP97JwDjdR3n_9mUc4l5MTIfJF7kTNRqwpM27HKWDYYLe72W_Wn0HnVRrS9n_M1VFsnkaAEA4tFO34HkIzZNcX_HOsCaYxcwm8Yr0Q1P8dC2SP_t6FbTzAxkO2cOsbsZO6b56MaeDK3olEhDHhBkFzfc0aTY7_CkIR8VwC5PoH0Lt1yCOhqQHmLzQsgpxz_XNW6F3L1J8gtYw2y9hjwnn7XbrL4rtzh4EuUgeGQb3_LVQbbmHbTgmkz6lGSqelKeG_xe6WZW0zksLqB_kEXmlBseBOm4xKMCt2DrMnRxZyxCco0-dBaeaySrD3unAuLp3H5FCg3iviK1SMpS5VAs-IQ-YR_DP1Db4xo_832U6uht5pwLA5O8edlbBJbB1mXI63F0GdthrtS4HRz79fSykILRKHDxUI6FXwH5LnxTNbwnpg7CN7YScdKvpkOwQg7jDIBr6_pF_Mdpg>

[5] <https://www.khanacademy.org/science/cosmology-and-astronomy/stellar-life-topic/cepheid-variables/v/why-cepheids-pulsate>

[6] <http://ogle.astrouw.edu.pl/>

[7] <https://en.wikipedia.org/wiki/Slowly_pulsating_B-type_star>