Asteroseismology constraints on dark photon

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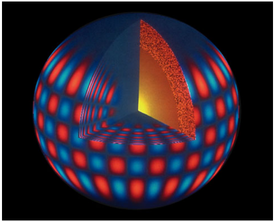

Overview of the presentation

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Asteroseismology in a nutshell

Asteroseismology

- Normal modes of pulsating stars
- Information about periods and frequencies
- Stellar properties : surface gravity, density
- Information about internal structure

Dark matter and Asteroseismology

Dark matter in stars

- Production or annhilation
- Energy or angular moment transport
- Changes respect to standard stellar evolution
- Changes in internal structure

Asteroseismic observables

- Structure changes $\Longrightarrow$ size of internal cavities
- Periods and frequencies are modified respect to standard scenarios
- Some parameters, as large separation could be modified: $<\Delta\nu>=\nu_{n+1}-\nu_n$

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Dark photons. An et al (2013); Redondo & Raffelt(2013)

Dark photon motivations

- Light bosons, extensions of standard model, $U_{(1)}$ field coupled to SM lagrangian
- Dark matter component
- $\mathcal{L} = -\frac{1}{4}F_{\mu\nu}^2 - \frac{1}{4}V_{\mu\nu}^2 - \frac{\chi}{2}F_{\mu\nu}V^{\mu\nu} + \frac{m_V^2}{2}V_{\mu\nu}V^{\mu\nu}$
- Kinetical mixing, χ, and m_V as free parameters

Dark photon production

- Plasmon oscillations
- Resonant longitudinal mode rates, proportional to plasma frequency
- RGB degenerate cores

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RGB models

Simulations

- $M = 1.0 - 1.6 M_{\odot}$, $Z = Z_{\odot}$, MESA
- Focus on RGB bump (Degenerate core, dark photon emission)
- 30 radial modes calculated by means of GYRE software
- We implement dark photon production (Plasmon L-resonant mode oscillation)
- $m = 1$ keV, $\chi = 10^{-15} - 10^{-14}$

Results

- At RGB bump phase central temperature and core mass decrease when χ increases
- Influence on asteroseismic predicted values

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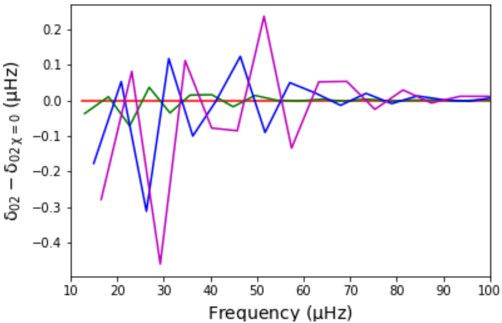
Asteroseismic parameters

Second difference parameter, $\delta_2\nu_{0n}$

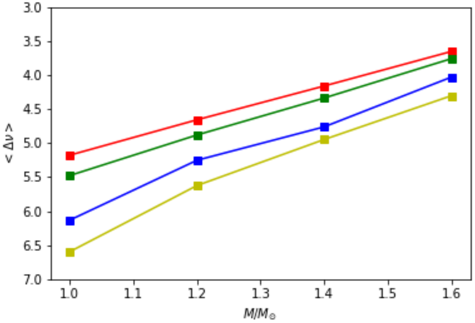
- $\delta_2\nu_{0n}$ increases with χ
- Hints of changes of internal structure, due to dark photon



Asteroseismic parameter

Large separation

- $<\Delta\nu>$ at bump increases with respect to χ
- Variations higher than observational errors (0.2 μHz)



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In progress

Next steps

- Compare models with data $\Longrightarrow$ RGB bump star observations (Kepler)
- Disentangle other effects: overshooting
- Look into other observables

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Some (preliminary) conclusions

- Bounds on χ could be put from stars at RGB bump
- Asteroseismology of post MS phases is an useful tool in Astroparticle Physics
- A study of the uncertainties (e.g. overshooting) is needed