Sources in the Medium Frequency Band

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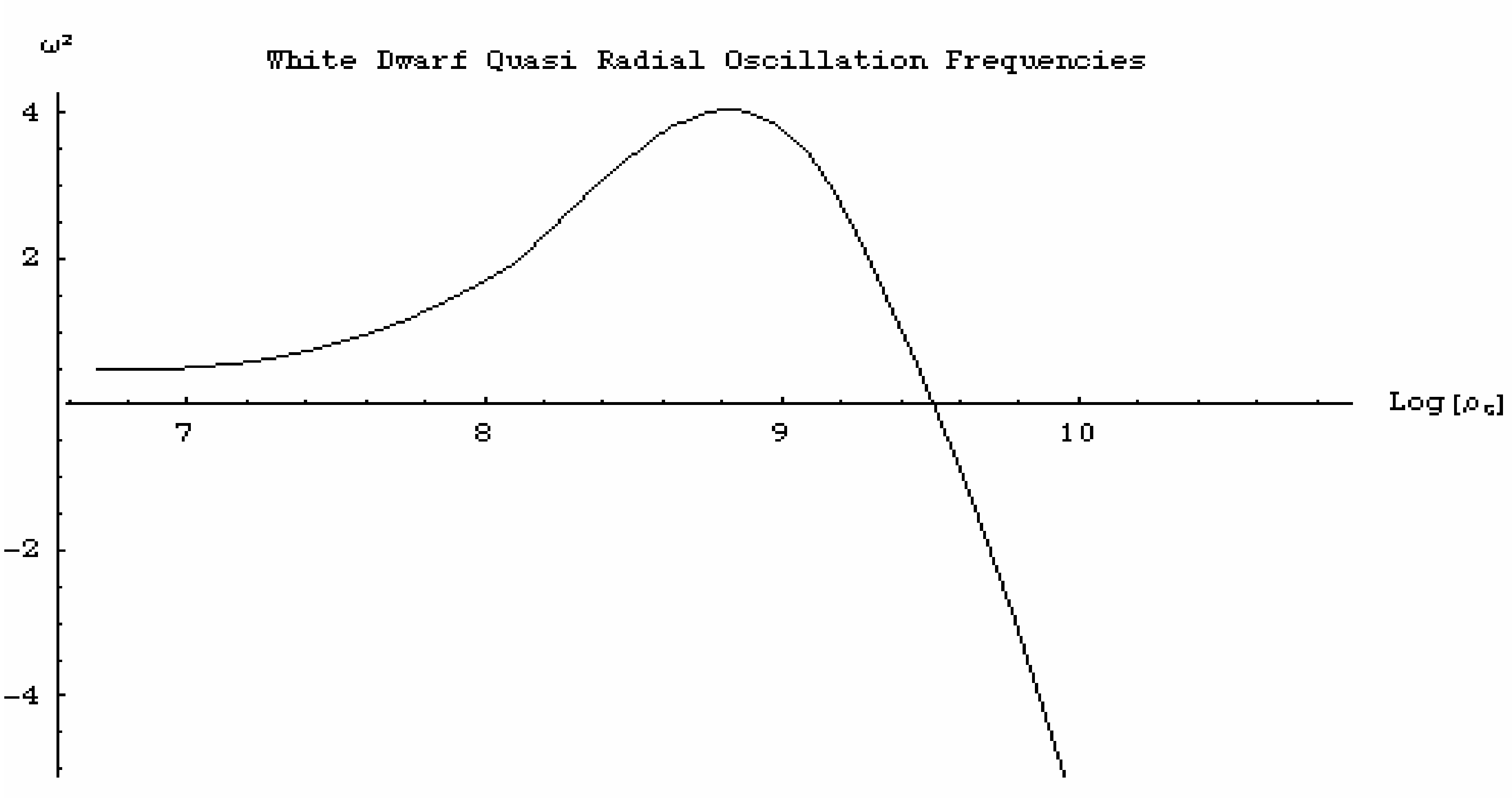
Motivation and Outline

- Motivation
  - Look for possible continuous sources in the band
  - Quasi-radial oscillations of rotating white dwarfs
- Outline
  - Identify frequency range
  - Determine gravitational radiation
  - Estimate stochastic background level

Identifying the Frequency Range



White Dwarf Properties and Resonant Frequencies

ρ_c (g/cm^3)	M_0 ($M_\odot$)	M ($M_\odot$)	Ω_{max}	Q^0_{max} (kg m^2)	ω
1.716×10^6	0.498	0.572	0.196	3.872×10^{42}	0.757
1.544×10^7	0.867	0.976	0.476	2.315×10^{42}	0.766
5.377×10^7	1.049	1.164	0.768	1.338×10^{42}	1.077
1.287×10^8	1.145	1.254	1.063	8.095×10^{41}	1.399
7.036×10^8	1.245	1.34	2.042	2.687×10^{41}	2.001
2.091×10^9	1.257	1.339	3.105	1.217×10^{41}	1.299

Determining Strain Amplitude

QuickTime™ and a Animation decompressor are needed to see this picture.

- Assume oblate shape due to rotation
- Oscillation is self-similar and is described by:

$$x_\alpha = x_\alpha^0\left(1+\eta\sin(\omega t)\right)$$

- Quadrupole moment given by

$$Q_{ij} = \int \rho\left(x_i x_j - \tfrac{1}{3}x^2\delta_{ij}\right)dV = Q_{ij}^0\left(1+\eta\sin(\omega t)\right)$$

Choose *z*-axis along rotation axis: $Q^0{}_{zz} = -2Q^0{}_{xx} = -2Q^0{}_{yy} = -2Q^0$

Polarizations

In TT gauge with *z*-axis along the wave vector:

$$h_+ = h_{xx} - h_{yy} = \frac{4GQ^0\eta\omega^2}{c^4 r}\sin^2\theta\sin(\omega t)$$

$$h_\times = 2h_{xy} = 0$$

where θ is the angle between the wave vector and the white dwarf axis of rotation

Estimating the Background Level

- Numerical calculations give $Q^0{}_{\text{max}}$ for select white dwarfs rotating at Ω_{max}
- Results are from an expansion in a dimensionless parameter proportional to Ω^2
- Use $Q^0 = (\Omega/\Omega_{\text{max}})^2 Q^0{}_{\text{max}}$
- Integrate over $\theta \Rightarrow \sin^2\theta \rightarrow {}^1/_2$

$$h_+ = 5.35 \times 10^{-65} \left(\frac{1\ \text{pc}}{r} \right) \left(\frac{\Omega}{\Omega_{\text{max}}} \right)^2 Q^0_{\text{max}} \omega^2 \eta$$

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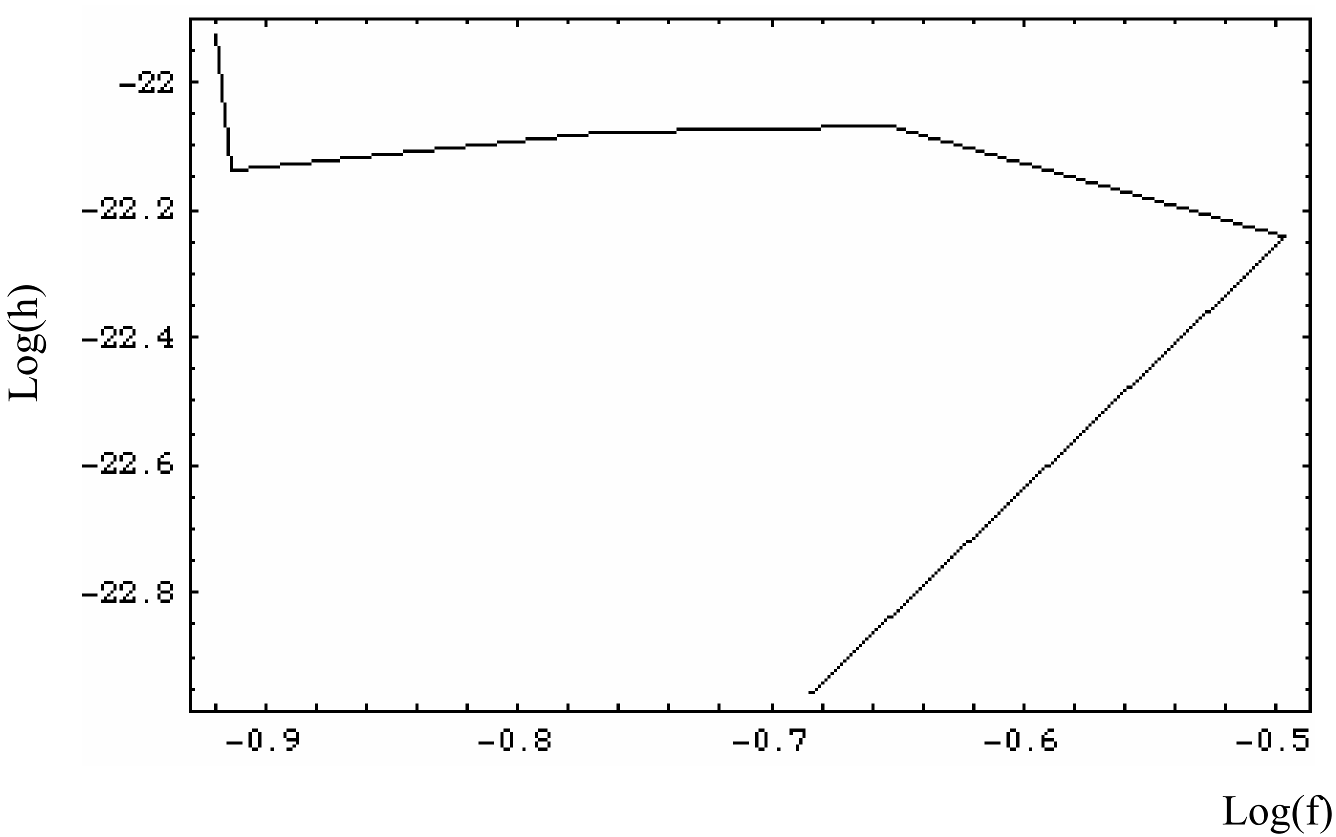
Expected Strain Amplitudes

- Maximum values (assume $\Omega = \Omega_{max}$)
- Assume r = 1 pc, $\eta = 10^{-4}$



Observed Rotation Rates

Kawaler (astro-ph/0301539)

- Spectroscopic methods:
  - $M \sim 0.6\ M_{\odot}$
  - $\Omega \sim 0.0036$ Hz
  - $h \sim 4.1 \times 10^{-26}$

- Asteroseismic methods:
  - $M \sim 0.6\ M_{\odot}$
  - $\Omega \sim 5.6 \times 10^{-5}$ Hz
  - $h \sim 9.7 \times 10^{-30}$

Conclusions

- Vibrating white dwarfs are potential sources of gravitational radiation in the mid-frequency range.
- Assuming a mean distance of r pc to nearest vibrating white dwarf, an upper limit of $\sim 10^{-23}/r$ can be placed on the expected level.
- If the high rotational rates of Kawaler are used, a more reasonable upper limit would be $\sim 10^{-26}/r$.
- If the low rotational rates are used, the upper limit is an almost negligible $\sim 10^{-30}/r$.
- Source of energy needs to be determined.
- Standard inflation gives $h \sim 10^{-27}$–10^{-29} in this frequency range.