Time Delay Of Gravitational Waves Propagating Through a Galaxy Toward a Non-Stationary Observer and Other Problems

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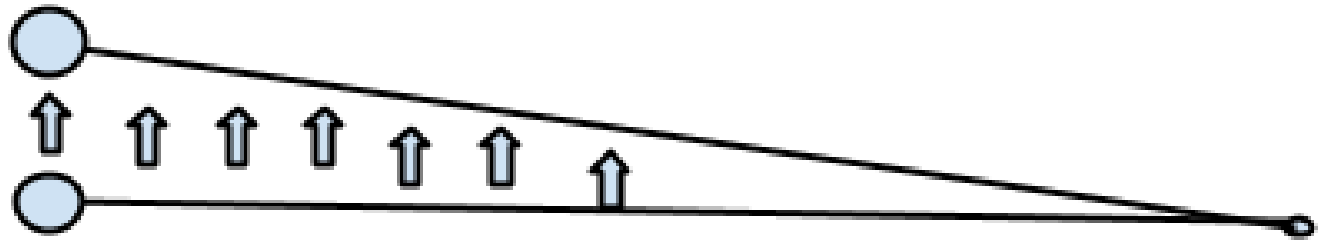
Original Plans and Motivation

- “Amplitude and phase fluctuations for gravitational waves propagating through inhomogeneous mass distribution in the universe” – Takahashi [1]
- “Hunting for topological dark matter with atomic clocks” – Derevianko and Pospelov [2]
- Simulation papers on domain walls as dark matter candidates – effectively excluded [3,4,5]
- “Domain Wall Dominated Universes” – Battyre, Bucher, and Spergel [6]

Time Delay Calculations

- $\Phi = \int \frac{M(r)}{r^2} dr$ $\quad g = \Delta\Phi \quad$ $\dot{t}_{delay} = \int v \cdot g \, dl$



Results

- Simple model of our galaxy: 1/r mass distribution out to $5 * 10^{20} m$, normalized to $6 * 10^{42} kg$ total, Earth positioned $2.6 * 10^{20} m$ from origin
- Maximum $\dot{t}_{delay} \sim 9.2 * 10^{-9}\ {}^{s}/_{s} \sim 0.29\ {}^{s}/_{yr}$ for the case of a source at infinity
- Maximum $\dot{t}_{delay} \sim 9.0 * 10^{-9}\ {}^{s}/_{s} \sim 0.28\ {}^{s}/_{yr}$ for the case of a source at a distance of 5 Mpc
- Maximum $\dot{t}_{delay} \sim 9.1 * 10^{-9}\ {}^{s}/_{s} \sim 0.28\ {}^{s}/_{yr}$ for the case of a source at a distance of 100 Mpc

Future work

- Find and use a more accurate mass distribution function for the galaxy
- Check on how significantly the slight discontinuity at the cutoff distance is effecting the results
- Other related problems

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References

1. Takahashi, Ryuichi. "Amplitude and phase fluctuations for gravitational waves propagating through inhomogeneous mass distribution in the universe." *The Astrophysical Journal* 644.1 (2006): 80.
2. Derevianko, Andrei, and Maxim Pospelov. "Hunting for topological dark matter with atomic clocks." *arXiv preprint arXiv:1311.1244* (2013).
3. Press, William H., Barbara S. Ryden, and David N. Spergel. "Dynamical evolution of domain walls in an expanding universe." *The Astrophysical Journal* 347 (1989): 590-604.

References cont.

4. Ryden, Barbara S., William H. Press, and David N. Spergel. "The evolution of networks of domain walls and cosmic strings." *The Astrophysical Journal* 357 (1990): 293-300.
5. Avelino, P. P., et al. "Dynamics of domain wall networks with junctions." *Physical Review D* 78.10 (2008): 103508.
6. Battye, Richard A., Martin Bucher, and David Spergel. "Domain wall dominated universes." *arXiv preprint astro-ph/9908047* (1999).
7. Kawamura, Seiji, and Yanbei Chen. "Displacement-noise-free gravitational-wave detection." *Physical review letters* 93.21 (2004): 211103.
8. Mathematica