Revisiting the laser interferometric 100 MHz gravitational-wave detector and the possible extension to a kHz detector

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Introduction

Long ago, a pair of synchronous recycling interferometers was constructed to observe 100 MHz gravitational waves (GWs). Each featured a 75-cm baseline ring cavity with a 3-m round trip length, matching the 100 MHz signals. The experiment established a new direct observational upper limit on the stochastic GW background in this frequency range. The core design of the ring cavity can be extended to kHz-band GW detectors. In this study, I applied a similar design concept to TAMA300, a 300-m baseline laser interferometer at the National Astronomical Observatory of Japan. Despite the relatively short baseline, the achievable sensitivity is reasonable.

100 MHz detectors

The core component is an L-shaped ring cavity, which effectively converts the tidal deformation by GWs into signal photons and enhances them through optical buildup. The matched GW frequency is equal to the free spectral range (FSR) of the cavity.





They were implemented closely together on the same breadboard. The signals were downconverted to the audio frequency range in a manner similar to radio techniques. Cross-correlation was then applied to further suppress uncorrelated noise.



Extension to kHz detectors

- An example when applied to the TAMA300 facility
- Effectively elongated the baseline with the FP cavities



Comparison: similar setups

- These setups resemble the proposal in this poster, but are intended for *low-frequency* or broadband sensitivity improvement.
 The upper-left setup is mostly equivalent to this proposal, but without FP cavities; their assumed raw baseline length is already 25 km.
- The two setups on the right (identical) are speedmeteres; the light travels along the L-shaped path for only a single round trip.

Future works

- Check the consistency of the calculation
- Evaluate thermal noise and the others
- Develop signal exstraction and control technique
- Demonstrate at a table top then TAMA300

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