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FROM:RW (August 5, 1989)

CONCERNING: Use of the third capability on the LIGO

RW opinions concerning the best means of using the ports for a third interferometer in the LIGO

I consider the best use of the third interferometer to be a full length system.

Arguments for this opinion

SCIENTIFIC

1) Equal sensitivity and bandwidth in all three interferometers for a burst search in coincidence.

2) Highest sensitivity for a periodic search using resonating techniques and for a stochastic background using resonating techniques placed at the frequency where stochastic force noise matches the Poisson noise in later phases of interferometer evolution.

OPERATIONAL

1) Capability to put a development version of the search interferometer into the third position. Most useful in the initial operations when having to make a compromise in the search interferometer to get on the air, and one would like to continue to make progress on improving the performance by testing new pieces. One could retain part of the initial idea of making the rapid interchange between the search and development system, now albeit only in one facility. The process would still be reasonably efficient even though we have to interrupt the search interferometer at the second site. The time consuming develpment work will have been done with a minimum cost in observing time at site 1. The installation at site 2 should be a lot shorter than the development time at site 1.

2) Some simplicity in the design of interferometer subsystems, equal diameter optics and servo parameters.

TECHNICAL

1) No chance of scattering by intermediate optical elements in the 1/2 length making noise in the full length.

2) Smaller circulating power for equal Poisson noise limit in full length than 1/2 length.

What are we really giving up if there is no midlength interferometer?

Since we are firmly planning two sites and three interferometers, we have covered the desire for the capability of making a triple coincidence experiment and if we make the third interferometer a full length system we have optimized our probability of making a reliable detection given three interferometers two of which have to share the same facility.

The remaining issue is how have we compromised the capability to do diagnostic studies on the interferometers themselves? The basis of the partial length interferometer concept

is the ratio of the gravitational wave signals in the full and partial length systems. The most primitive ratio of the measured optical phase sensitivity of a full length to a half length system of equal storage times are: 2 for gravitational waves, 1 for stochastic forces common to the two interferometers, 1 for gas bursts common to the two interferometers, unknown for common electronic and EMI noise. However, the ratios cannot be unique for all cases, for example suppose that a seismic wave approaches broadside to one arm of the interferometer, this will make a common mode noise in both the partial length and the full length interferometer and will only give the ratio 1 if the isolation transfer functions of the suspensions are the same. The ratio is not defined at all for such an example.

I have made a truth table for various cases of noise excitations and find that there is no unique inversion of the table to find a cause for a specific noise term by using both the partial length and the full length system (nor is it possible for a pair of full length interferometers). So that the diagnostic capability to determine the source of a common mode noise that we want to find and fix will have to come from other techniques such as a monitoring system. What remains is the ratio 2 which is unique to gravitational waves except for those special cases such as the one mentioned above. There may be others which I haven't thought of .