Data analysis of laser-interferometer and wavelength sweep control

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We are developing a long-baseline laser-interferometer to observe crustal deformation, especially that due to short-term and long-term slow-slip events. We explain our data processing method of Michelson interferometer and absolute length measurement by wavelength sweep.

In an Michelson interferometer, we measure photo-power of two orthogonally plane-polarized light with pi/2 phase-shift. It is necessary to extract phase change of the light from the photo-sensor output to detect length change.

Data plot of the photo-power on (x,y) plane makes a Lissajous figure. We tried to fit an ellipse to the data plots. We can use distance from the ellipse center as a measure of data misfit from a give ellipse. We decompose the residual into an average, (cos phi, sin phi), and (cos2phi, sin2phi). It is considered that those components correspond to misfits of size of the ellipse (a+b), center coordinate (x0,y0), and oblateness ((a-b)/a) or rotation angle (theta), respectively. The most suitable ellipse could be found by correcting these parameters iteratively.

Level of photo sensor output may change due to electronic fluctuation. Those fluctuations can be corrected by using interpolated ellipse parameters. On the other hand, it would be difficult to fit an ellipse when data plots are distributed in a part of the cycle. For the case, data of longer period is processed so that enough data would be distributed on the ellipse.

If laser output or photo-sensor output is interrupted, continuous observation of the crustal deformation become impossible. For example, when ground shaking by an earthquake moves the laser ray angle, photo-sensor output would break off and it would get impossible to observe strain step by the earthquake. We planed to observe absolute length by wavelength-sweep technique (Katsumata *et al*., 2005) to cope with interruptions of the measurement.

We are making a wavelength-sweep laser system. We use an iodine-stabilized Ne-Ne laser made by Neoark. The laser system is made of two lasers, an iodine-stabilized laser and an offset-lock laser. Offset frequency can be set by a mechanical switch in the laser system. We altered the laser system so as to make it possible to change the offset frequency by a computer digital output. We can get an absolute length from the relationship between interferometer output and beat frequency of two lasers. We are testing the offset-frequency control by a computer now.

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