**FFT based Complex Interferometry, Abel Inversion & Transformation: Principles, Applications and Current Status**

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Classical *interferometry* is one of the key methods among *active* optical diagnostics. A more advanced version of this diagnostics, which allows *recording* and subsequent *reconstruction* of up to *three* sets of data using just *one* data object—a *complex interferogram*—was developed in the past during measurements of *self-generated magnetic fields* in laser-produced plasma and became known as *complex interferometry* (*CI*). Employing this diagnostics not only the usual *phase shift*, but also the *amplitude* of the probing beam as well as the *fringe* *contrast* (leading directly to the phase shift *time derivative*) can be reconstructed *simultaneously* from such a complex interferogram using FFT approach.

Several practical CI applications will be demonstrated together with its gradual development. The CI current status will be overviewed and its strength supported by numerical tests. In particular it will be proven that even in the case of a not particularly good diagnostic beam *quality* the three quantities embedded in complex interferograms (*phase shift*, *amplitude* and *fringe contrast*) can be reconstructed with a high degree of *accuracy* provided both the *diagnostic beam* as well as the corresponding *optical line* feature a reasonable *stability*. Such stability requirement is important as in an ideal case *four* shots need to be gradually recorded (one by one): the *signal* complex interferogram, the *reference* interferogram as well as the *intensity* structure of the *signal* and *reference* part of the *diagnostic* beam. Analysis of two complex interferograms obtained in experiments will be presented together with intentionally low quality computer simulated data in order to demonstrate the strength of the algorithm. Additionally it will be shown how an *asymmetric* diagnostic beam temporal profile can produce a *systematic error* in the *phase shift* reconstruction.

Review of FFT based *Abel Inversion* algorithm using *special functions* developed uniquely for this purpose will be provided and its potential demonstrated on illustrative sets of data in order to prove its quality – in particular from the point of view of details which can be secured. Moreover, also FFT based *Abel Transformation* algorithm will be presented. Similar to FFT based *Abel Inversion* a set of novel *special functions* was developed. This makes very easy to go the *opposite* way, e.g., to get back the *phase shift* from *density*. Thus having the chance to check *reliability* of the *density* profile obtained by the *Abel Inversion* from the original *phase shift* by performing a direct comparison of the both *phase shift* data sets. This feature is rather useful as quite often, in order to get decently looking *densities*, some artistic approach or over-filtering has been used by the researchers. And unless there is a chance to perform the above check, it is difficult to judge, how correctly that *density* is related to the original *phase shift* (and reality).