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Sede Secondaria di Padova

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Review of the Thesis: "Wavefront Correction for Mid-IR Laser" of Huang Zhou

The thesis is about an adaptive optics system for Mid IR laser sources. The PhD candidate Huang Zhou realized a thin disk laser system for the BIATRI project at HiLASE Center and a complete adaptive optics system and tested it. In the AO system he realized the wavefront sensor and all the software for the wavefront control.
The thesis is well written and the candidate obtained excellent results. The thesis developed different aspects from laser development to adaptive optics using a novel type of sensor for the wavefront measurement. This is remarkable and I have appreciated the level obtained in this thesis.

Some minor remarks and suggestions:

The survey of available cameras in the IR presented in chapter 2.1.4 is very important for this thesis. I suggest to expand it adding a table that summarizes the main parameters of all available cameras (for example, type of sensor, resolution, sensitivity, spectral region, Noise level and other important aspect such as cooling or not and others,ad then pros and cons). The table 4.1 could be used as template just adding pros and cons column. This will allow for an easy overview of available technologies and to easily compare them. The comparison table will also be useful for supporting your choice of using VPD PbSe FPA camera instead of other sensors.
Section 4.1: this section should include also comments on drawbacks of this sensor.

On page 42: Fi_min calculated by the ration of pix/f (2.3) is not a good approximation. This sentence is too vague:
"The measurement sensitivity in this work is $1/\theta min$= 1/0.09 mrad-1 with a minimum detectable displacement of 0.01 pixel, which is our estimation based on estimations for similar algorithms"
The wavefront sensor error due to SNR of the detector can be estimated using a proper formula. You can find it for example in the Adaptive Optics Field Guide (Tyson) in "Shack Hartmann wavefront sensor and error" section or in other textbooks from Tyson.

Section 5.3.1: to obtain optimal performance with the deformable mirror the laser beam must match the actuators aperture of the deformable mirror. The deformable mirror that is used in this thesis has to work with a beam of 22mm aperture while the laser is declared to be 17mm. Rhis limits the high order aberration correction.

All the work presented in chapter 5 to improve the accuracy of the wavefront measurement with dynamic updating of the background is remarkable.

The results shown in Fig. 5.40 show a good wavefront correction results. Anyway there is still room for improvement.
The focal spot in Fig. 5.36 shows high spatial frequencies features for sure connected with high order aberrations. For this reason the AO system must be well tuned in order to obtain a full correction.

My recommendations for future improvements are:

- The wavefront error must be reduced in order to obtain a good DM calibration and a good correction.
- A method to check the wavefront sensor accuracy and calibration would be to compute PSF by intensity and wavefront data. They should result be exactly the same of the focal spot intensity acquired with a far field camera.
- As mentioned above the laser beam must match the DM size. This is very important to be sure that the DM is able to correct high order aberration.

Most Sincerely,

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