Fast beam pointing stabilisation system for Astra

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Introduction

Much of the low-energy part of the Astra laser chain has already been fitted with an automatic alignment system [1,2] to combat slow drifts in beam position. At the high-energy end of the chain, small deviations in beam position are less critical because of the large beam diameter, but the beam pointing direction, which is equivalent to the far field or focal spot position, becomes all the more important. Therefore, a dedicated system was developed for stabilising the far field position. To reach the highest possible stability, the feedback loop was designed to operate at the same update rate as the laser repetition frequency of 10 Hz.

Setup

The schematic setup of the system is illustrated in Fig. 1. The beam leaking through an HR turning mirror is focused by an f=1m lens and imaged through a microscope objective onto a CCD camera (Marlin F033B, Allied Vision Technologies). Active control of the beam direction is provided by mirror on a piezo-driven kinematic mount (KC1-PZ, Thorlabs), connected to a high-voltage driver (MDT693A, Thorlabs). The system was installed as late in the chain as possible to maximise the on-target stability of the focal spot position.

The control software was written in LabView and runs on a Windows PC. The software reads in the focal spot image from the camera through the FireWire interface, calculates the centroid position of the spot and the required change in piezo voltages and sends the new voltage values (one each for the horizontal and vertical directions) to the driver via an RS232 link. A screenshot of the software is shown in Fig. 2.

Results

Running the control loop at a 10 Hz update rate proved to be no problem. The response time of the piezo-driven mirror was also found fast enough, despite the mirror and the 2” adapter for holding it being fairly heavy.

To assess the improvement in pointing stability, the system was run with different control gain settings and the position data gathered during these runs was then spectrally analysed. The result is shown in Fig. 3. Changing the control gain from 0 (control turned off) to increasingly higher values leads to an increase in stability in the low frequency (0-1 Hz) range. A too high gain leads to an increase in fluctuations in the high frequency part, probably because of overshoot. The best overall RMS stability (over a measurement time of approx. 4 min) was reached for the 0.6 gain setting where it was improved by a factor of 1.3 compared to the 0 gain setting.

Conclusions

A fast beam pointing stabilisation system based on a piezo-driven mirror was successfully installed on the Astra laser system. It led to a reduction in beam pointing fluctuations up to a frequency of 1 Hz. As the system update rate is 10 Hz, it should however be possible to improve stability at higher frequencies. This can probably be achieved through a modification and appropriate tuning of the control algorithm.

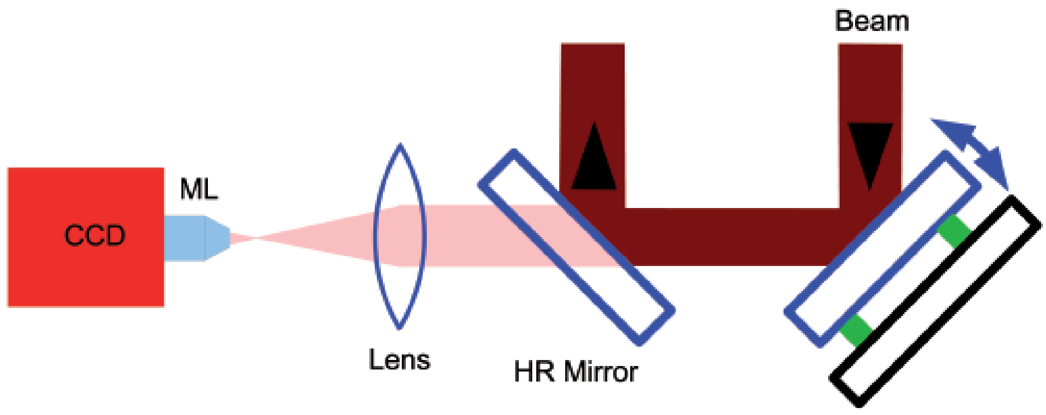

Figure 1. Schematic setup of system.

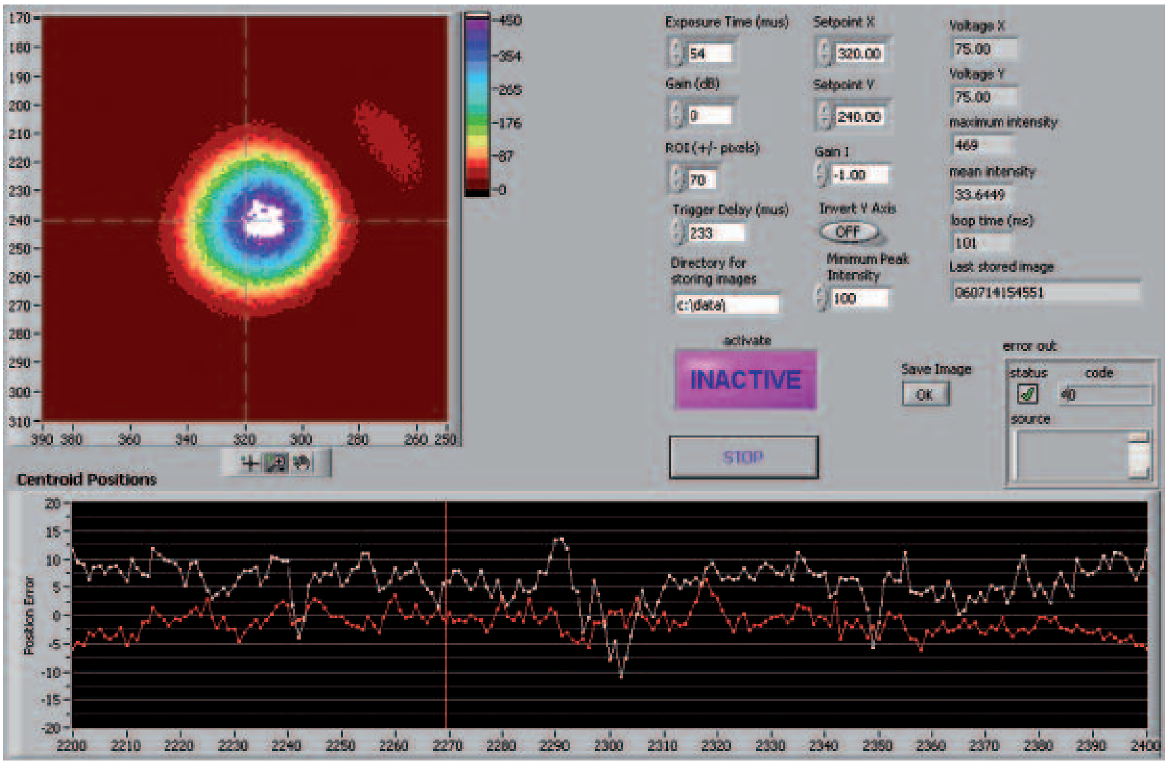

Figure 2. Screenshot of control software.

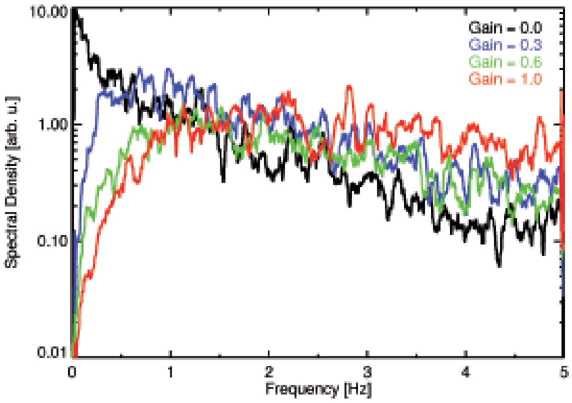

Figure 3. Variance spectra of beam position for different control gain settings.

References

1. K. Ertel, E. J. Divall, C. J. Hooker and J. L. Collier; Automatic beam alignment system for Astra, first stage, CLF Annual Report, RAL-TR-2006-025, 187, (2006).
2. K. Ertel, C. J. Hooker and J. L. Collier; Automatic beam alignment system for Astra: second stage, CLF Annual Report, RAL-TR-2007-025, 1717, (2007).