Laser frequency stabilization using purely optical reference

A. Rossi, V. Biancalana

INFM UdR Siena - Department of Physics, University of Siena, Via Banchi di Sotto 55, 53100 Siena, ITALY

We describe an apparatus for the stabilization of laser frequencies that prevents long term frequency drifts. A Fabry-Perot interferometer is thermostated by referencing it to a stabilized He-Ne laser (master), and its length is scanned over more than one free spectral range allowing the analysis of one or more lines generated by other (slave) lasers. A digital acquisition system makes the detection of the position of all the laser peaks possible, thus producing the feedback signals both for the thermostat and for the stabilization of the slave lasers. This technique also allows for easy, referenced scanning of the slave laser frequencies over range of several hundred MHz, with a precision of the order of a few MHz. This kind of stabilization system is particularly useful when no atomic or molecular reference lines are available, as in the case of rare or short lived radioactive species. This problem has already been faced and successfully solved in the framework of laser-cooling experiments involving short-lived radioactive species [1, 2], for which no atomic vapor can be used. Our implementation simplifies the one described in [1] by using a thermal control of the optical cavity length, instead of compensating the thermal drift with piezo actuators, thus making the use of high-voltage offset on the piezo unnecessary. This choice is similar to the one reported in [2] and it makes the piezo response more constant in time. Actually, the response of piezo actuators is non-linear, and the large values of DC offset needed to compensate thermal drift of the cavity length may dramatically change the slope of the response and hence the effect of the AC scanning signal. For this reason, differing from [1], we do not need a continuous re-calibration of the scan following the variation of the piezo response. The same result could be achieved by using two separate actuators for thermal compensation and for scanning, nevertheless our solution is easier and also allows for simpler construction of the cavity, because no fused quartz, invar or other materials with low thermal coefficient are needed. In fact, the compensation of the slow thermal drift of the cavity length does not need the fast response of a piezo actuator to be accomplished, moreover the thermal control does not suffer of the small range compensation which is intrinsic in the piezo. In our case the optical cavity was home-made in aluminium, cheaply produced by a common tool machine. The system is fully controlled by a computer program which operates a commercial 12 bit ADC-DAC card. The program was developed in order to achieve relatively fast operation, continuous control of the cavity response, flexible adjustment of the feedback parameters, and on-time visual monitoring of the laser spectra. No external electronics are needed apart from a very simple voltage-to-current converter used to supply the cavity heater. We used the program to stabilize only one laser with respect to the He-Ne, but other laser lines can be added and referenced with straightforward extensions of the program. In particular with this system we plan to stabilize a Ti:Sa ring laser working at 718 nm and a diode laser working at 817 nm, which will be used as cooling and repumping lasers in an experiment of

magneto optical trapping (MOT) of Francium be used as a feedback for other kinds of externally controllable lasers.

[1] W. Zhao, J. E. Simsarian, L. A. Orozco, and G. D. Sprouse; A computer based digital feedback control of frequency drift of multiple lasers; Rev. of Scient. Instr., **69**, 3737, (1998).

[2] E.Riedle, S.H. Ashworth, J.T.Farrel Jr., and D.J.Nesbitt; Rev. of Scient. Instr., **65**, 42, (1994).

[3] S. N. Atutov, V. Biancalana, A. Burchianti, R. Calabrese, L. Corradi, A. Dainelli, V. Guidi, B. Mai, C. Marinelli, E. Mariotti, L. Moi, A. Rossi, E. Scansani, G. Stancari, L. Tomassetti, S. Veronesi; Production of Francium ions for TrapRad; Annual Report INFN-LNL 2001, in press; L. Moi, S. N. Atutov, V. Biancalana, A. Burchianti, R. Calabrese, L. Corradi, A. Dainelli, V. Guidi, B. Mai, C. Marinelli, E. Mariotti, A. Rossi, E. Scansani, G. Stancari, L. Tomassetti, S. Veronesi; Laser Cooling and Trapping of Radioactive Atoms; SPIE, Proceed. of XVII int.Conf. on Coherent and Nonlinear Optics (Minsk 26/06-01/07 2001).