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LELA: A FREE ELECTRON LASER ON ADONE

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The LELA (Laser ad Elettroni Liberi su Adone) experiment has been designed in order to study the feasibility of a Free Electron Laser (FEL) on a high energy electron storage ring.

After the first successfull experiment in 1977 on the Stanford Superconducting Linac, several FEL projects have been completed in the following years, all of them, but one, using low energy electron beams and obtaining a radiation in the microwave or infrared wavelength region.

Storage rings provide excellent beam characteristics to realize a FEL with a radiation from the visible to the X-ray region. The recirculation of the beam and its continuous interaction with the radiation, which is one of the most attractive feature of this device, produces, on the other hand, severe problems to the dynamics of the beam itself.

The success of the experiment on the storage ring ACO at Orsay has only partially solved these questions due to the reduced dimension of the ring and its low operating energy (180 MeV).

After the installation of the LELA electromagnetic undulator of 20 periods, accurate measurements of the spontaneous radiation have been performed[1].

The gain has been measured[2-4] using an external argon laser, obtaining a value of 3×10^{-4}. This number has to be considered as a lower value due to the difficulty to align the laser to the electron beam, but in every case it is too low to obtain the laser oscillation. A sensible increase of this value can be obtained by modifying the magnetic structure of the ring in order to obtain a vanishing dispersion function in the undulator straight section.

Due to the lack of electron orbit diagnostic tools on Adone, this feature, already foreseen in the experiment project, has encountered some difficulties to be implemented, however we hope to have it in full operation at the end of the long shut-down of this year. In this way we can increase the gain by a factor 3-4.

In the mean-time we have installed the optical cavity which, due to the low value of the gain, has to be completely under vacuum and directly connected to the accelerator pipe[5,6].

The necessity of synchronizing the optical pulses reflected in the cavity and the electron bunches requires the cavity length to be equal to half the distance between two successive bunches. This fixes a length of 17.506 m, with a tolerance, to optimize the gain, of 15 μm. For the same reason, the alignment of the optical axis of the cavity to the electron beam direction has to be kept within 15 μrad. All the technical requirements have been fulfilled using a remote control system[7] based on step motors and, for the fine mirror tilts, on undervacuum piezoelectric translators. All the movements are controlled by a computer to take care of the intrinsic nonlinearity of the piezoelectric translators and of the inaccessibility of the cavity during the machine running.

In all alignement operations the radiation outgoing from the cavity is the only feedback signal we have. We succeeded in this hard task during the first months of 1986.

In the alignment tests we had the opportunity to give an insight into one of the most critical aspects of low wavelength FELs. That is the damage of dielectric mirrors due to higher harmonics of the spontaneoue radiation[8,9].

The large K value of our undulator implies that significant power is emitted in the UV and soft-X regions. As consequence of this radiation we have measured, on one mirror, a reflectivity decrease from 99.8% to about 70% after an exposure to 800 mAh.

Different mechanisms seem to be responsible for this damage. In order to partially reduce it, we made an effort to lower the vacuum value in the cavity zones near the mirrors by doubling the pumping power and reducing the impedance of the whole vessel.

Significant improvements in the damage rate have been obtained with this new lay out.

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