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We continued a program of studying micropole insertion devices. These were originally proposed by us[1] to increase the quality, such as coherence, of photon beams radiated by relativistic electron beams. Further, these devices have the capability of reducing the capital cost, as well as operating expenses associated with synchrotron radiation sources.

During the last year we developed a new magnetic configuration,[2,3] one which under certain operating conditions is capable of generating higher radiated intensities than the one previously used. It is expected to become a particularly powerful tool in conjunction with highly relativistic electron beams, such as those available in the PEP ring at Stanford. We carried out calculations to study the performance of micropole insertion devices[4] in storage rings, as well as the behavior of undulators[5][6] for which the magnet gap, g, is large compared to the period, λ. This configuration is of limited interest for conventional insertion devices, but can become valuable in the short period limit, when $\lambda/g \to 0$. Undulator radiation spectra were observed[7] on the new undulator beamline at ALADDIN in Wisconsin. Finally, the performance of micropole undulators was tested and analyzed in a series of experiments, originally begun last year. The linac beam at the Lawrence Livermore National Laboratory was passed through micropole devices of various parameters, and the generated soft x-ray radiation was measured[8],[9].

We performed calculations to evaluate the behavior of thin layered interference mirrors in the general case when more than one type of dielectric separates the successive conducting layers from each other.

Dynamical x-ray optics was proposed by us as a means of reducing the length of x-ray pulses[10] and altering the coherence properties of photon beams. Subsequent investigations showed that it can also be employed to provide reflectors whose focal length can be altered in a continuously variable fashion. We proceeded to investigate the capabilities of this new technique, particularly for purposes of saturating the transverse coherence of beams of energetic photons, such as x-rays.

A problem related to the construction of synchrotron radiation pumped x-ray lasers was studied, with a view of designing insertion devices optimized to generate radiation with a frequency and spectrum best suited to be used for pumping. It was realized that electrostatic, as opposed to magnetic, devices with variable periods can be constructed in a fashion which will insure superior performance in comparison with conventional magnetic devices.[11]

1) Micropole Undulators for Storage Rings and Linear Accelerators

These devices, originally suggested by us, are expected to become new tools for research in basic and applied science[1]. Their compatibility with various types of relativistic electron beam machines, is an important topic which has to be well understood. We have shown that a variety of designs appears to be within reach by todays technology. We propose to continue exploring these in a systematic and orderly fashion, placing particular emphasis, as we have done in the past, on their predicted behavior in circular machines, especially the SPEAR and PEP rings at Stanford. Further studies of magnetic and other errors as well as design inaccuracies will continue to be a component of the theoretical studies to be performed. Comparison with experimental results has been, and is expected to be employed by us to evaluate our understanding of the phenomena. For that reason it is hoped that during the coming year it will be possible to obtain additional data on the spectrum of radiation emitted by an appropriate lineac electron beam passing through various micropole insertion devices.

Our long range goal is to have this topic of research funded independently of the present grant. We intend to concentrate our efforts within the present program on exploring subsequent novel ideas.

2) Dynamical Photon Optics

In the area of photon beam physics research, considerable effort has been spent over the years to improve coherence and instantaneous intensity, as well as to control pulselength. These efforts have encountered serious obstacles in the high energy range. It appears[10] that dynamical optical techniques can provide a means to overcome those obstacles, at least partially. We propose to study the extent to which this approach may allow the generation of high radiation intensity environments over macroscopic volumes. If that proves to be feasible, it would permit the exposure and testing of a variety reactions and instrument responses which heretofore could not be accomplished in the laboratory. Furthermore, we plan to explore the potential of these techniques for enhancing the transverse coherence of x-ray beams generated by high energy electron storage rings.

3) Novel Particle Acceleration Mechanisms

Within the framework of our ongoing program to survey and explore novel particle acceleration mechanisms, we intend to evaluate the impact of dynamical optical techniques on the guiding and accurate positioning of high intensity accelerating fields.