A CONCEPT FOR A QUASI-PERIODIC PLANAR SUPERCONDUCTING UNDULATOR*

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Abstract

A request from the light source user community for insertion devices that provide only monochromatic light has led to development of quasi-periodic undulators (QPUs). These devices generate shifted harmonics in the photon energy spectrum, thus allowing suppression of higher harmonics by optical monochromator systems. Until now such undulators have been technically realized with pure permanent magnets or with hybrid structures. A concept for a superconducting quasi-periodic undulator (SCQPU) is suggested and described in this paper.

INTRODUCTION

Development of short-period undulators is of great interest to light source users as this new class of insertion devices can lead to higher brightness at high photon energies. The importance of developing short-period superconducting undulator technology is highlighted in [1].

An intensive R&D program is underway at the Advanced Photon Source (APS) aimed at developing a full-scale superconducting undulator as discussed in [2].

A possible means of creating a quasi-periodic undulator based on superconducting technology was recognized during the R&D phase of the project. Such a device would generate shifted harmonics in the photon energy spectrum, thus allowing suppression of higher harmonics by optical monochromator systems [3]. A concept for a superconducting quasi-periodic undulator (SCQPU) is described in this paper.

CONCEPT OF SCQPU

The present SCQPU concept is based on the superconducting undulator (SCU) design that is under development at APS. Magnetically this undulator consists of two half-magnets with a beam pipe in between, as illustrated in Fig. 1. Each half-magnet is made with a set of small race-track superconducting coils wound into the grooves cut in the core. The current flows in opposite directions in adjacent windings.

Magnetic calculations performed with the OPERA electromagnetic simulation codes show that the core can be made of non-magnetic material without decreasing the peak field of the device, as long as there are magnetic poles between coils on the working side of the half-magnet. Therefore Al and Cu can be used for the core to take advantage of their more desirable thermal properties at cryogenic temperature, but the poles must be made of iron or another magnetic material. The latest version of the design exploits the idea of making u-shaped iron poles that are inserted into precise grooves cut into the core. This concept for an assembled design was recently tested by making the 10-pole prototype shown in Fig. 2.

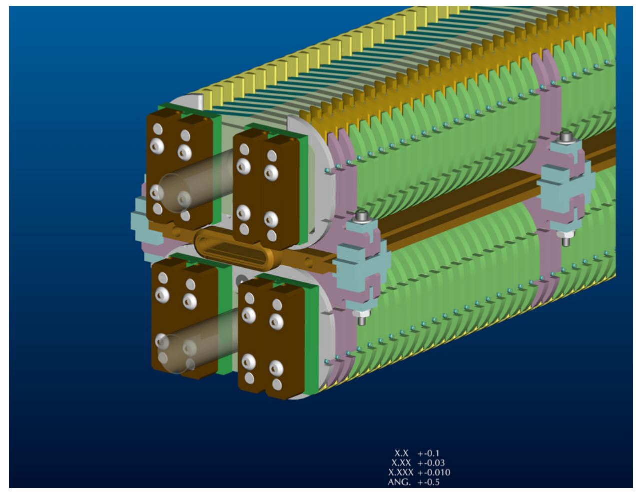

Figure 1: Magnetic structure layout of a superconducting planar undulator.

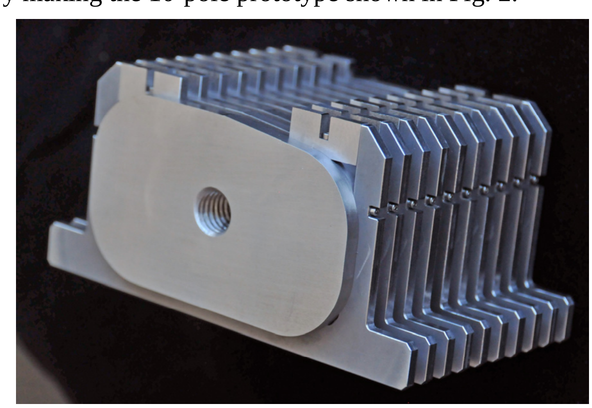

Figure 2: A 10-pole test Al core. The poles are separate pieces assembled onto the central core.

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The scheme for making a quasi-periodic SCU is based on the observation that, in the magnetic structure described above, there is a strong dependence of the undulator peak field on the iron pole height. OPERA 2d calculations show that the peak field varies by about 50% when the magnet pole height changes from 0 mm to about 10 mm, as shown in Fig. 3.

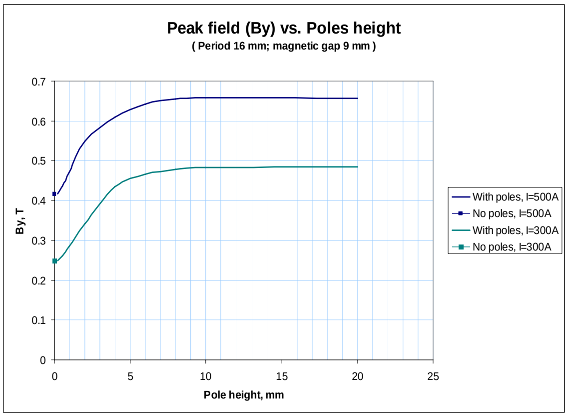

Figure 3: Dependence of peak field on the iron pole height.

Therefore the field profile in the device can be modified by varying the heights of individual magnetic poles or more simply by replacing some of the iron poles with non-magnetic poles made of Al alloy, for example. A simulated field profile for a short structure with magnetic poles 5 mm high and two non-magnetic poles in the middle is shown in Fig. 4.

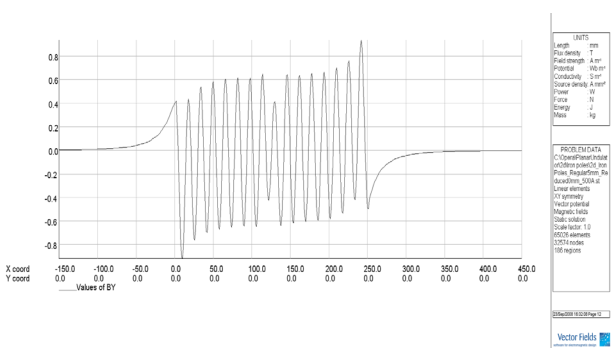

Figure 4: Simulated field profile for a short-length magnetic structure with two non-magnetic poles in the middle.

EXPECTED PERFORMANCE OF SCQPU

The expected spectrum of on-axis flux density at 30 m downstream from the source point is shown in Figure 5. The APS nominal emittance of 2.5 nm-rad and 100-mA beam current were assumed for this calculation. Figure 6 shows the SCQPU field distribution used for the calculation.

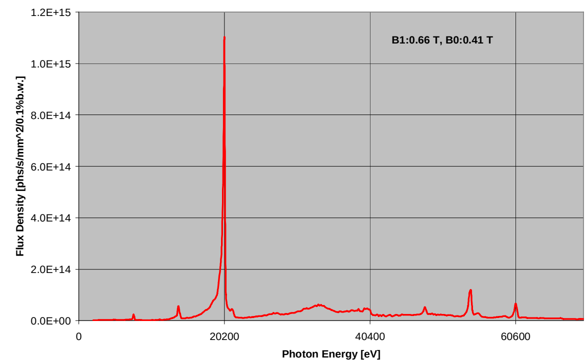

Figure 5: Calculated on-axis photon spatial flux density from SCQPU.

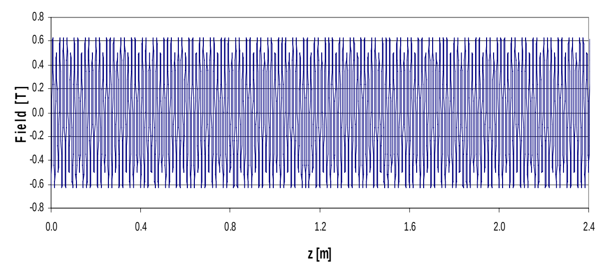

Figure 6: Magnetic field distribution along the undulator axis used in calculation of the photon flux density.

CONCLUSION

A superconducting planar undulator is currently under development at the Advanced Photon Source. The design of the undulator magnetic structure allows simple conversion of a conventional device into a quasi-periodic device by replacing some of iron poles in the magnetic structure with non-magnetic poles before the undulator is wound with superconducting wire. In such a way either a conventional undulator or a quasi-periodic device could be built depending on user preference.

REFERENCES

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[2] Y. Ivanyushenkov et al., “Status of R&D on a Superconducting Undulator for the APS,” these proceedings.
[3] S. Sasaki, “Overview of Quasi-Periodic Undulators,” these proceedings.