STATUS OF RF SUPERCONDUCTIVITY AT ARGONNE NATIONAL LABORATORY

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Introduction

Argonne National Laboratory now has two groups working on the application of rf superconductivity to particle accelerators. In the Physics Division, work in RFSC began in 1971 and led to the first superconducting heavy-ion accelerator (ATLAS). Recently, work has focused on the upgrade of the facility by replacing the existing tandem injector by a new positive ion injector comprised of an electron-cyclotron-resonance source and a very-low-velocity superconducting linac.

In the Engineering Physics Division, a new group was started in 1987 with the purpose of developing the superconducting technology for high-current, high-brightness linacs.

Additionally, both groups collaborate in some areas of generic technology development.

RFSC Developments in the Physics Division

Since the first operation of a superconducting heavy-ion linac in 1978,[1] the number and size of this class of accelerator has steadily increased.[2] Previously, all the machines have been post-accelerators, increasing the energy of beams from tandem electrostatic accelerators. The largest of the post-accelerators is the ATLAS linac, completed in 1985.[3] Performance of the ATLAS facility has been limited by characteristics of the 9 MV tandem injector to mass $A < 127$ and to beam currents of typically a few particle nanoampere for the heavier ions.

Several years ago, the Physics Division undertook to replace the tandem portion of ATLAS with a new injector which would provide greatly increased beam current, and extend the mass range of ATLAS to uranium.[4,5] The positive ion injector (PII) project was motivated by the availability of electron-cyclotron-resonance (ECR) sources which can provide highlypositively-charged ion beams with good transverse and longitudinal emittance. The technical goal has been to incorporate an ECR source into a superconducting linac injector which maintains and exceeds tandem-like beam quality while matching the beam into ATLAS.

Construction has proceeded in several phases. First, the technology for a very-low-velocity superconducting linac was developed.[6,7] At the same time an ECR source was designed and built on a high voltage platform. The source, beam transport, and a small (3.5 MeV) portion of the linac were completed and tested in early 1989. In 1990, the system was operated with 7 MV of linac installed. When completed, the injector will provide 12 MV and will accelerate uranium ions up to 1 MeV/A, enough for ATLAS to accept the beam and further accelerate to $\approx$ 8 MeV/A.

Further upgrades of ATLAS are likely and being discussed. One such possible upgrade is the development of a superconducting rf bunch separator to permit simultaneous delivery of the ATLAS beam to two experiments.

In addition, the Physics Division has initiated a long-term technology development effort to address more fundamental issues in RFSC. Initially, the effort will focus on the study of electron loading in low-velocity structures.

RFSC Developments in the Engineering Physics Division

The RFSC program in the Engineering Physics Division, begun in 1987, has focused on the development and extension of the RFSC technology for high-current, high-brightness accelerators with most of the effort directed toward light-ion beams. This area of application of the RFSC technology has been unexplored until now and has required a new look at all the important aspects of low-velocity superconducting accelerators.[8,9]

The issues that we have addressed as part of this work, either experimentally or theoretically include:

--Resonator geometry for higher velocity and frequency than previously developed for ions.[10,11]

--Materials development[12]

--Focusing of space-charge dominated beams

--Study of beam instabilities[13,14]

--Study of beam impingement

--Development of control systems for heavily-beam-loaded, low-velocity superconducting structures.

This work is more fully described in another contribution to this workshop.[15]

Collaborative Work

In addition to the work described above, members of the two groups collaborate on experiments of general and generic interest in RFSC. One such collaboration investigated the maximum surface electric fields that could be achieved in an rf quadrupole geometry.

In that experiment, an existing ATLAS-type niobium split-ring structure was modified by installing fingers on the drift tubes. This way, a region was created where an rf quadrupole field was generated. During the low temperature tests, cw surface fields of 128 MV/m were sustained over an area of the order of 10 cm^2; that limit was set by the cooling of the fingers. Higher fields, up to 210 MV/m, could be sustained for several milliseconds by reducing the duty factor of the rf power.[16]

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