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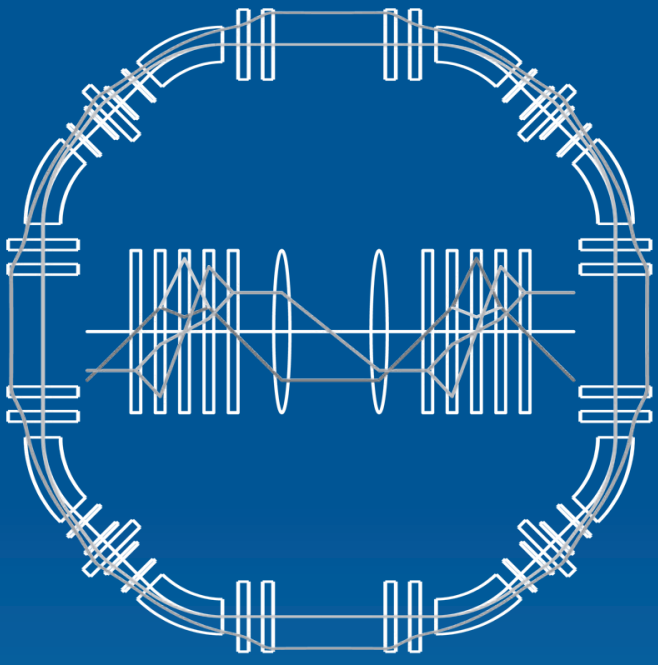

Martin Berz, Kyoko Makino and Weishi Wan

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Preface

This volume provides an introduction to the physics of beams. This field touches many other areas of physics, engineering and the sciences, and in turn benefits from numerous techniques also used in other disciplines. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group, so that the motion is a weakly nonlinear perturbation of that of a chosen reference particle.

Applications of particle beams are very wide, including electron microscopes, particle spectrometers, medical irradiation facilities, powerful light sources, astrophysics – to name a few – and reach all the way to the largest scientific instruments built by man, namely, large colliders like LHC at CERN.

The text is based on lectures given at Michigan State University's Department of Physics and Astronomy, the online VUBeam program, the US Particle Accelerator School, the CERN Academic Training Programme, and various other venues. Selected additional material is included to round out the presentation and cover other significant topics.

The material is at a level to be accessible to students of physics, mathematics and engineering at the beginning graduate or upper division undergraduate level and can be viewed as an introductory companion to the more advanced *Modern Map Methods in Particle Beam Physics* by M. B., published by Academic Press. Emphasis has been placed on showing major concepts in their original incarnations and through historic figures. Finally, some of the sections and chapters that contain more advanced material are marked by a * symbol and can be omitted in a first reading.

Many organizations and individuals have helped directly and indirectly at various stages in the development of this book. MSU's Physics and Astronomy Department provided an environment of support for this and other books, the VUBeam program, as well as many of our other activities.

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Martin Berz
Kyoko Makino
Weishi Wan

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An Introduction to Beam Physics

Martin Berz, Kyoko Makino and Weishi Wan

The field of beam physics touches many areas of physics, engineering and the sciences. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group so that the motion is a weakly nonlinear perturbation of a chosen reference particle. Particle beams are used in a variety of areas, ranging from electron microscopes, particle spectrometers, medical radiation facilities, powerful light sources and astrophysics to large synchrotrons and storage rings such as the LHC at CERN.

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