Physics of Collective Beam Instabilities in High Energy Accelerators

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to Patricia, Clifford, and Laura

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Preface

When I was a graduate student in Stony Brook, I wanted to become a high energy physicist. Then, in 1973, Professor Chen Ning Yang suggested that I learn a subject called accelerator physics. In the same year, Professor Ernest Courant started my learning process with an introductory course in accelerator theory. Later in 1974 as I was working on my thesis, Professor Yang advised me to consider accelerator physics as my career choice after my graduation. This advice I considered, debated, and eventually followed. For eighteen years since my graduation, I have thoroughly enjoyed this rich field of physics. One of the reasons for this enjoyment is what I will describe in this volume—the subject of collective beam instabilities in accelerators. Over the years, I have learned and been fascinated by this subject, and it is this fascination that I would like to share with the reader.

Beam physics is a branch of physics that studies the dynamics of charged particles, particularly in accelerators. This is a maturing field; much nurturing is needed, including a need of textbooks. The subject of collective beam instabilities is one of the main topics facing modern high performance accelerators. The knowledge is crucial for the successful design and understanding of these accelerators. This book is intended to provide the basics of this subject of beam physics.

I have assumed that the reader is knowledgeable in classical electrodynamics and mathematical physics at a lower graduate level. Previous knowledge of accelerators would be helpful but is not required. I have not pursued the more advanced research topics. Instead, my aim is to prepare the reader with a sufficiently broad basis of the subject for him/her to pursue his/her own research. References are restricted to those related to the discussions, and are not meant to be exhaustive.

Various collective instability effects for high energy accelerators are introduced and analyzed. The material is theory oriented, and the emphasis is on the underlying physical principles of these instabilities, typically using models and soluble examples as illustrations. Experimental observations are mentioned when appropriate.

I have tried to postpone formalism till a fairly solid intuitive picture has been established. Therefore, the conventional treatment of the subject using the Vlasov techniques is postponed to a later part of the book. This I regard as a humble achievement on my part.

The book is an outgrowth of several lecture series, delivered on various occasions since 1982. I wish to thank the students for their enthusiasm, their comments, and their difficult questions. In the preparation of the manuscript, I have enjoyed and benefited from innumerable discussions with my colleagues, among them Karl Bane, Dick Cooper, Miquel Furman, Tom Knight, Sam Kheifets, Phil Morton, Bob Siemann, and many others. Jacques Gareyte, Albert Hofmann, and John Seeman have kindly provided photos of their experimental observations. Special thanks must be given to Mel Month; the existence of this book is a result of his many encouragements.

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