Project No. G-41-638 (R5437-5A0)
Project Director: Dr. Joseph Ford
Sponsor: Department of Energy
Oak Ridge Operations, TN

Type Agreement: Mod. A004 to Contract De-As05-81ER40003

Award Period: From 12/1/84 To 11/30/85 (Performance) 11/30/85 (Reports)

Sponsor Amount:
Estimated: $ 77,000
Funded: $ 77,000

Cost Sharing Amount: None
Cost Sharing No: N/A

Title: Dissipative Effects in the Beam-Beam Interaction of Intersecting Storage Rings

Modification No. A004 adds $77,000 as follow-on to G-41-651. New project number is required because of separate financial reporting requirements. Also, deletes name of Franco Vivaldi as Co-Principal Investigator and acknowledges name change from GTRI to GTRC.

Total contract value (including previous project numbers) $326,000

COMMENTS:

MODIFICATION:
Revision No. A004 adds $77,000 as follow-on to G-41-651. New project number is required because of separate financial reporting requirements. Also, deletes name of Franco Vivaldi as Co-Principal Investigator and acknowledges name change from GTRI to GTRC.

Total contract value (including previous project numbers) $326,000

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 4/25/86

Project No. G-41-638

Includes Subproject No(s) N/A

Project Director(s) Dr. Joseph Ford

School/Dept. Physics

Sponsor Department of Energy, Oak Ridge Operations, TN

Title Dissipative Effects in the Beam - Beam Interaction of Intersecting Storage Rings

Effective Completion Date: 11/30/85

(Performance) 11/30/85 (Reports)

Grant/Contract Closeout Actions Remaining:

[X] Final Invoice or Final Fiscal Report (Statement of Costs)

[ ] Closing Documents

[ ] Final Report of Inventions

[ ] Govt. Property Inventory & Related Certificate

[ ] Classified Material Certificate

[ ] Other

Continues Project No. G-41-651

Continued by Project No. G-41-606

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FORM OCA 68-285
GEORGIA TECH RESEARCH CORPORATION
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332-0420

24 July 1985

U. S. Department of Energy
Division of High Energy Physics
Mail Stop ER-224, GTN
Washington, D.C. 20545

Attention: Dr. Richard Sah

Subject: Renewal Research Proposal Entitled, "Dissipative Effects in the Beam - Beam Interaction of Intersecting Storage Rings"
Contract No. DE-AS05-81ER4003

Gentlemen:

The GEORGIA TECH RESEARCH CORPORATION desires to submit for your consideration the following items prepared by Dr. Joseph Ford of the School of Physics, Georgia Institute of Technology:

1) Renewal Proposal (six copies)
2) Progress Report (six copies) with completed DOE Form IR-427
3) Notice of Energy RD&D Project - Form DOE 538 (six copies)

We believe that the proposal is complete; however, if you desire anything additional, please do not hesitate to contact Dr. Ford at 404/894-5255 for technical matters or the undersigned at 404/894-4817 for administrative concerns.

Sincerely,

Earnestine P. Smith
Contracting Officer

EPS/kfh

Addressee: Six (6) copies
Enclosure: Proposal - Six (6) copies
In the following section, we discuss the work we have performed under previous award.

II. PROGRESS REPORT ON PREVIOUS AWARD : DE-AS05-81ER40003,A004

Our research has led to the following publications:


In Ref. A above we examine the limitations that chaos imposes on the predictions obtainable by any dynamical theory. We relate the notion of chaos to that of randomness through algorithmic complexity theory. We then discuss critically the meaningfulness of determinism, existence-uniqueness, and formal solutions in various dynamical systems. We show that in presence of chaotic behaviour the computation of orbits is a problem having positive complexity, posing severe logical limitations to the actual predictability of the motion. For the case of classical dynamics, we present evidence that these limitations should be regarded as the "generic" physical situation, implying a need to revise the logical framework of this physical theory.

In Ref. B above we review the topics that have been named "chaos" seeking to provide a unifying view. We stress that chaos means randomness in the sense of algorithmic complexity theory. From this point of view, we discuss some of the most significant manifestations of chaos, both classical and quantum (if any). We indicate why chaos should be regarded as richness rather than pathology, and why chaos is pointing toward a new world view for science.

In Ref. C above we examine the problem of the transition to stochasticity in a quantum nonlinear oscillator driven by a periodic perturbation. Diffusive absorption of energy is observed, which is found to be related to a continuous component in the spectrum of the periodic evolution operator. Numerical evidence is presented which confirms the thesis that this
continuous component is actually a singular continuous one. In
relation to the problem of the semiclassical limit, we discuss the
extent to which classical chaos may persist in the quantum domain.
Since the existence of a continuous spectrum has been established
for a generic set of perturbing potentials \[18\], the quantum
instability we have detected is expected to be relevant to a large
class of dynamical systems, such as models for beam dynamics near
parametric resonances.

In Ref. D above we consider a two-dimensional Hamiltonian model
of the beam-beam interaction for proton-antiproton colliders with
bi-gaussian charge distribution in the strong beam. For special
values of some parameters (equal tunes and cylindrically symmetric
charge distribution), an integral of the motion is known to exist
\[19\] which permits reduction to a one degree of freedom system. We
consider a broader range of parameter values but still lying near
the above "degenerate" values; here reduction to one degree of
freedom system is no longer possible. We investigate both
analytically and numerically the influence of the broken integral
of the motion on medium and long time stability of particles in the
weak beam. We detect the presence of weak instabilities and
compute the associated diffusion coefficient. Our results predict
strong sensitivity of the anti-proton lifetime on the tune, in the
proximity of the main coupling resonance.

In Ref. E above, we treat analytically the problem of decay of
correlation functions of physical observables in the model of the
Wigner Gaussian Unitary Ensemble of Hermitean matrices. We
extended the usual application of this model as far as to a generator of a dynamical evolution through a semigroup of unitary operators. The relevance of this extension may go beyond the specific application we present. We verify a strong decay of such autocorrelation functions up to a critical time related to the dimensionality of the matrix ensemble. Proper asymptotic formulae are devised to show that, letting the dimension of the space go to infinity, the above decay is effective for the dynamics of almost all the Hamiltonians in the ensemble and over an arbitrary long time. The connection of these results with the theory of transient stochasticity [21] is discussed.

In Ref. F above we consider the problem of detecting chaotic behaviour in dynamical systems in the realistic case in which only finite-accuracy measurements are permitted. We find that measurements of local instability of motion (i.e. entropy) are the only tests capable of discriminating between truly chaotic motions and complicated regular ones.

III. PROPOSED RESEARCH

Our future research will be devoted to developing analytical and numerical techniques for determining the long-time behaviour of particles in proton-antiproton storage rings when small dissipative effects are taken into account. The aim of this work is to be able to determine optimal parameter ranges with a minimum amount of
Title: Dissipative Effects in the Beam-Beam Interaction of Intersecting Storage Rings

1. DOE Report No. DOE/ER/40003-4
2. Contract No. DE-AS05-81ER10003, A004

4. Type of Document ("X" one)
   □ a. Scientific and technical report
   □ b. Conference paper:
      Title of conference
      Date of conference
      Exact location of conference

   □ c. Other (Specify Thesis, Translations, etc.) Contract Renewal Proposal

5. Recommended Announcement and Distribution ("X" one)
   X a. DOE's normal announcement and distribution procedures may be followed.
   □ b. Make available only within DOE and to DOE contractors and other U.S. Government agencies and their contractors.

6. Reason for Recommended Restrictions

7. Patent information
   Does this information product disclose any new equipment, process or material? □ Yes □ No
   Has an invention disclosure been submitted to DOE covering any aspect of this information product? If so, identify the DOE (or other) disclosure number and to whom the disclosure was submitted. □ Yes □ No
   Are there any patent related objections to the release of this information product? If so, state these objections.

8. Submitted by
   Name and Position (Please print or type)
   Dr. Joseph Ford, Regents' Professor
   Organization
   School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332
   Signature

9. Patent Clearance ("X" one)
   □ a. DOE patent clearance has been granted by responsible DOE patent group.
   □ b. Report has been sent to responsible DOE patent group for clearance.
   □ c. Patent clearance not required.

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