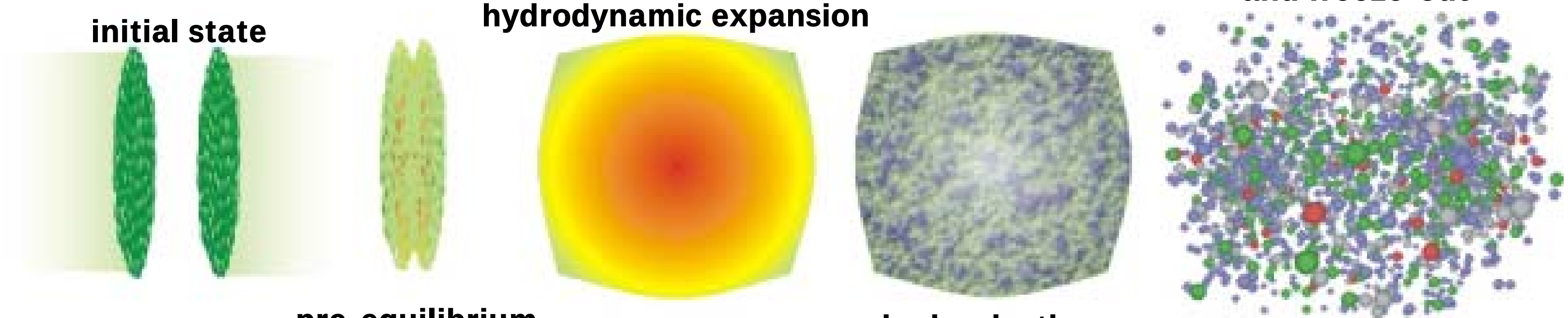
Dynamic Modeling of RHIC Collisions

Steffen A. Bass

Duke University &
RIKEN BNL Research Center

- Motivation: why dynamic modeling?
- Overview: current status of Transport-Theory at RHIC
- Key physics questions to be addressed by Transport Theory
- Computational and personnel requirements
- Summary: most pressing points

The Purpose of Dynamic Modeling

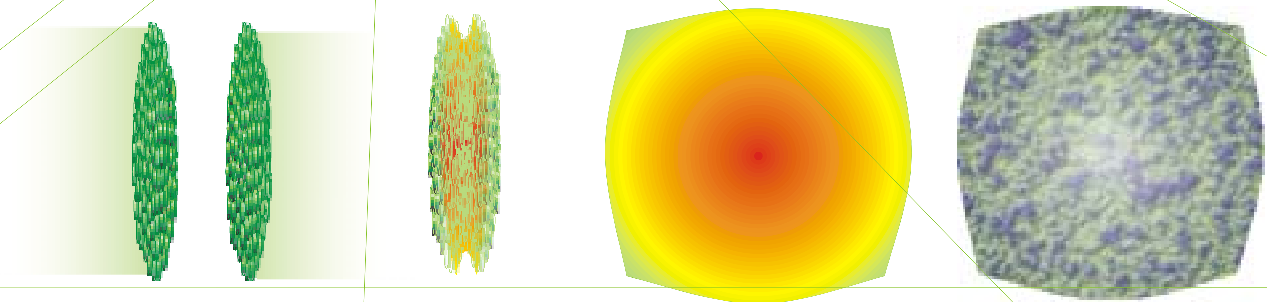


Lattice-Gauge Theory:
- rigorous calculation of QCD quantities
- works in the infinite size / equilibrium limit

Experiments:
- only observe the final state
- rely on QGP signatures predicted by Theory

Transport-Theory:
- full description of collision dynamics
- connects intermediate state to observables
- provides link between LGT and data

Transport Theory at RHIC



& LGT

Key Physics Issues for Microscopic Transport

- Decoherence
  - how do the gluon wavefunctions of the colliding nuclei evolve?
- Thermalization
  - how does the system of q's and g's thermalize to form a QGP?
  - is chemical equilibration achieved?
  - what are the time-scales for thermalization?
- Dissipative Effects
  - what are the transport coefficients (e.g. viscosity) of a QGP?
- Refinement of microscopic concepts for observables
  - detailed understanding of jet-quenching and EM probes
- Hadronization
  - what is the microscopic mechanism for hadronization?
- Final State Effects
  - what are the effects of hadronic rescattering on observables?
- Creation of a Standard Model

Hardware Requirements

- Small CPU farm
  - 10-20 CPUs (Intel/Linux), US$ 20K-30K (incl. server, disks and archival)
- Medium size CPU farm
  - 25-100 CPUs (Intel/Linux), US$ 35K-100K (incl. server, disks and archival)
- Large size CPU farm / parallel array
  - 150 CPUs, special parallel architecture, US$ 200K+

	S	M	L
Decoherence			✓
Thermalization		✓	
Dissipative Effects	✓	✓	
Specific Observables	✓	✓	
Hadronization		✓	
Final State Interactions	✓	✓	
Standard Model		(✓)	✓

- computer hardware has a life-cycle of 3 years and needs to be replaced after that (continuous funding!)
- to maintain integrity of research, several groups should address the same question – multiplier for resources!
- support personnel as additional cost factor

Personnel Requirements

	faculty	postdocs
Decoherence	1+1	2
Thermalization	1	2
Dissipative Effects	1	2
Specific Observables	2	3
Hadronization	1+1	3
Final State Interactions	1	1-2
Standard Model	1+2	4+

- estimates are for one University group working exclusively on the respective question
- numbers exclude personnel for system management
- for integrity of research several groups should address the same question: multiplier for personnel!

- a collaboration among several groups would be able to make use of different areas of expertise and resources at the respective institutions
  - a project coordinator (5 year research faculty)
  - 2-4 postdocs under the supervision of that coordinator
  - the individual institutions would contribute 30% to 50% of the research time of their faculty & postdocs towards the collaborative research

Current Personnel in RHIC Theory and Phenomenology

	faculty	postdocs
Duke University	2	2
McGill University	2	1
Texas A&M	2	2
BNL	3	1
Columbia U.	1	1
LBNL	1	1
Michigan State	1	1
Ohio State	2	1
SUNY Stony-Brook	1	1
Univ. of Minnesota	1	1

- numbers do not reflect reality with respect to personnel available for dynamic modeling:
  - senior faculty rarely develop novel algorithms and write code
  - RHIC Theory and Phenomenology cover a multitude of topics outside of dynamic modeling

Funding and Access to Resources

- currently no funding scheme exists to provide University groups with the computing infrastructure necessary for the undertaking of research in dynamical modeling for RHIC
- the investment and upgrade/replacement cost for a medium size cpu-farm are on the order of the entire annual research grant for a University group with 1 faculty and 2 postdocs/graduate students
- ➢ a separate (additional) funding scheme is needed to provide the necessary computing infrastructure!
- access to existing computing clusters has been sparse and involves overcoming high administrative hurdles
- providing improved computing resources would allow the research groups to tackle more ambitious projects and help attract young talent to this area of RHIC physics

Summary

The status and quality of RHIC theory in general and transport theory in particular lags behind that of the experiments by a fair amount – increased community and financial support for RHIC theory is needed to bridge that gap!

- Dynamical Modeling will be instrumental to the success of the RHIC program, by connecting the data to the properties of the deconfined phase and rigorous Lattice-Gauge calculations.
- Hardware resources necessary for this research require additional funding, both for initial investment as well as for regular replacement and upgrades.
- Current manpower in the field is insufficient to tackle the most relevant questions to be addressed by Transport Theory – additional manpower and collaborative concepts are needed.