Machine learning for classifying the chiral phase transition in AdS/QCD

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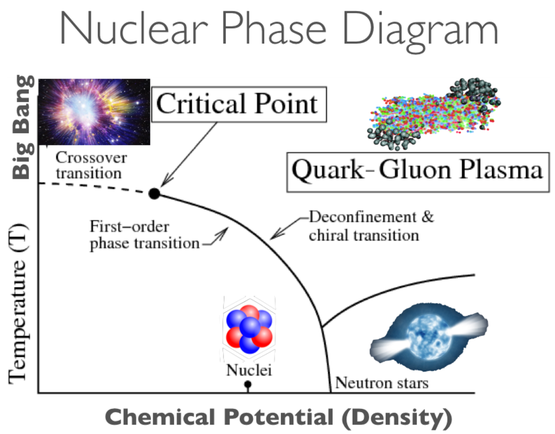
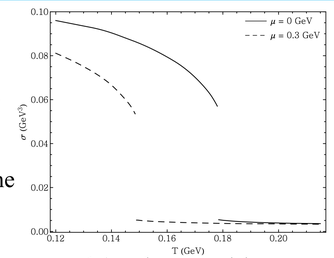
Introduction – Physics Background



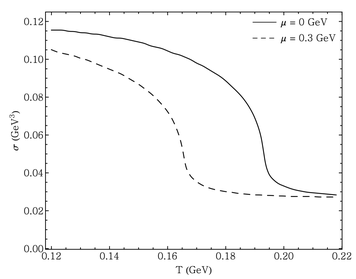
Quark-gluon plasma (QGP) occurs at high temperature and density. The quarks and gluons move freely, and the plasma behaves like a perfect liquid. We analyze the phase transition from ordinary nuclear matter.

Transition Types

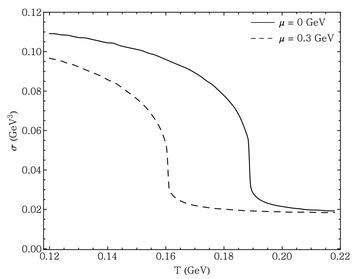
- Chiral parameter σ measures difference in behavior between particles with left-handed spin and particles with right-handed spin
- σ = 0 indicates plasma formation
- We are interested in the *order* of the phase transition



1st order transition



Crossover transition



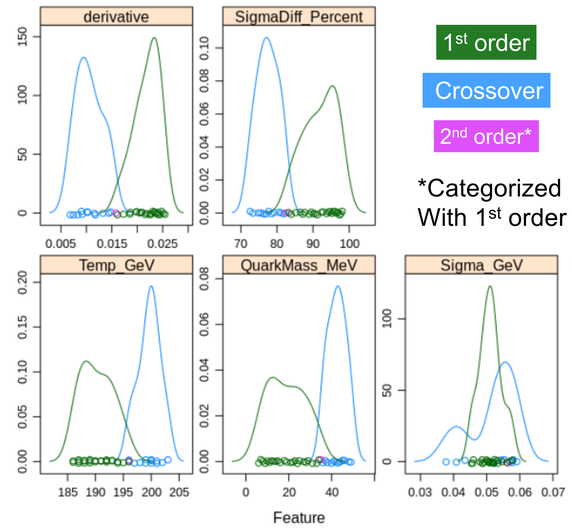
2nd order transition

Machine Learning Model

Types of input data for machine learning

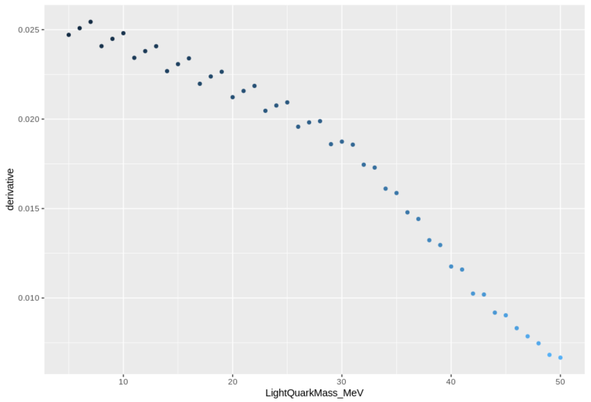
1. **Maximum derivative of chiral parameter σ**
2. **Percent change of chiral parameter**
3. Temperature at maximum derivative
4. **σ value at maximum derivative**
5. Quark mass

Bolded variables are used in the machine learning method



1st order
Crossover
2nd order*

*Categorized With 1st order



- Maximum derivative is an indicator of the phase transition type
- 1st order at small quark mass
- Crossover above 35 MeV

The machine learning model combines four classification algorithms:

1. classification and regression trees (CART)
2. k-nearest neighbors (kNN)
3. support vector machines (SVM) with a linear kernel
4. random forest (RF).

Training vs. Testing

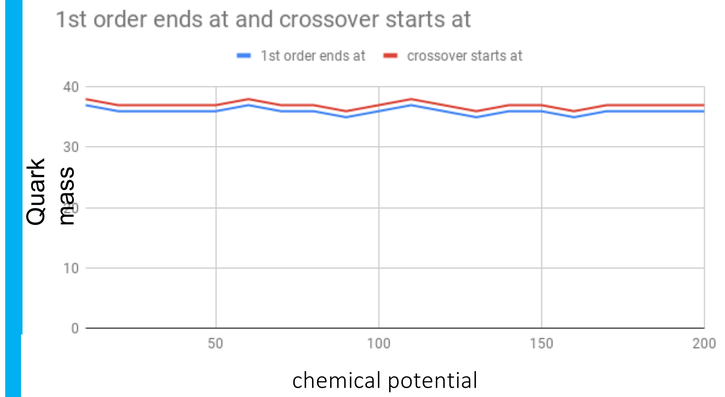
3 flavor model:
Light quark mass equals strange quark mass

2 +1 flavor model:
Quark masses can differ

Model	Training Data	Testing Data	Success Rate
3 flavor	80% randomly selected	Remaining 20%	100%
2+1 flavor	Chemical potential = 0	Chemical potential = 300	100%

Application

We test the machine learning method on a physics model with known behavior



We will use machine learning to develop a physics model with realistic phase transitions.

Acknowledgements

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