Holographic Meson Melting on an Anisotropic Background

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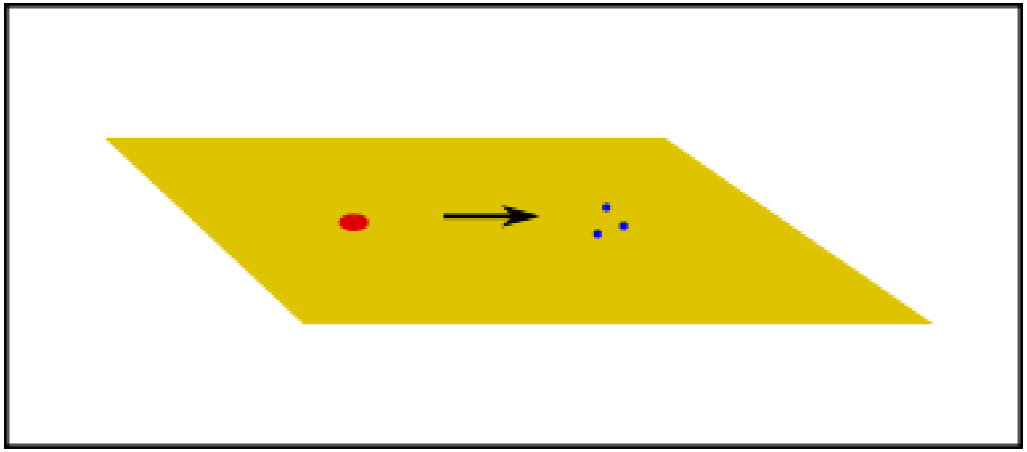
Meson Melting

Meson Melting

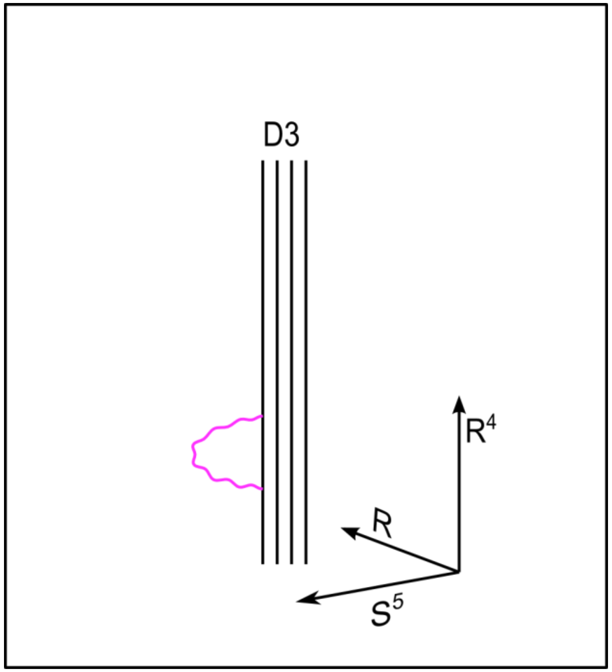
- The number of Quarkoniums are suppressed in Heavy Ion Collisions.
- The most important reason is screening the quarks by the Medium.
- If we imagine a Hadron in the plasma, we expect it to be melted after a while.
- There is a non-zero Melting Time.
- We expect the Meson Melting to be closely related to Quarkonium Suppression.

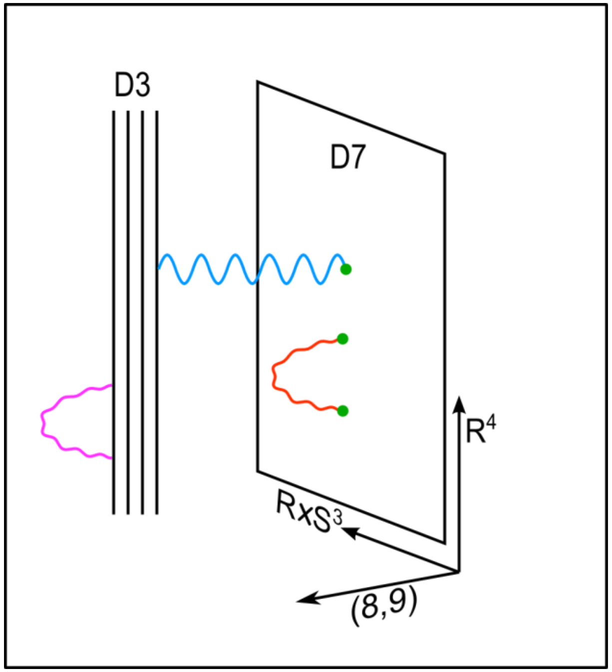


Mesons in Holography

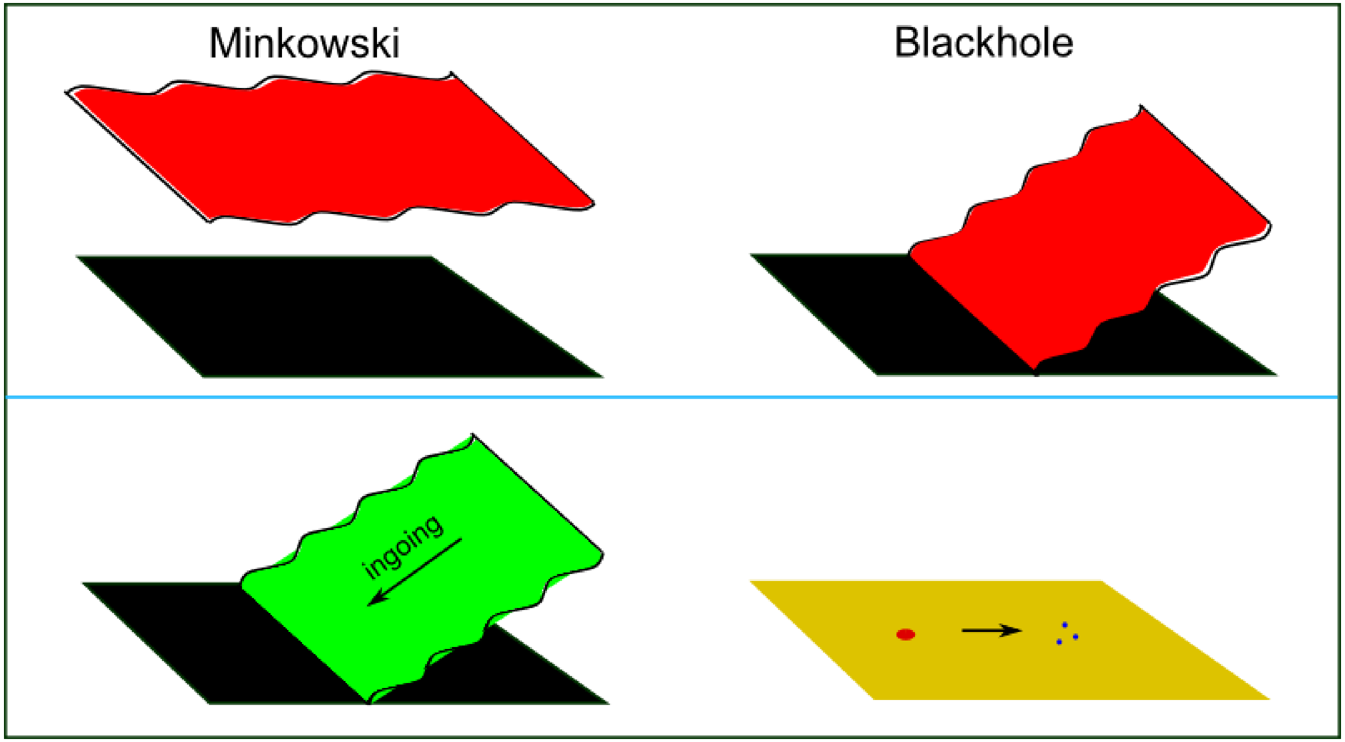
Quarks and Mesons in top-down Holography

- N_c D3 Branes $\rightarrow$ SU(N_c) gauge symmetry.
- Strings are in adjoint representation of the gauge group.
- Adding N_f Flavor branes $\rightarrow$ SU(N_f) Gauge symmetry $\rightarrow$ SU(N_f) Flavor symmetry.
- We have flavored quarks.
- Coordinates perpendicular to the brane are scalar fields correspond to meson-like scalar operators in field theory.





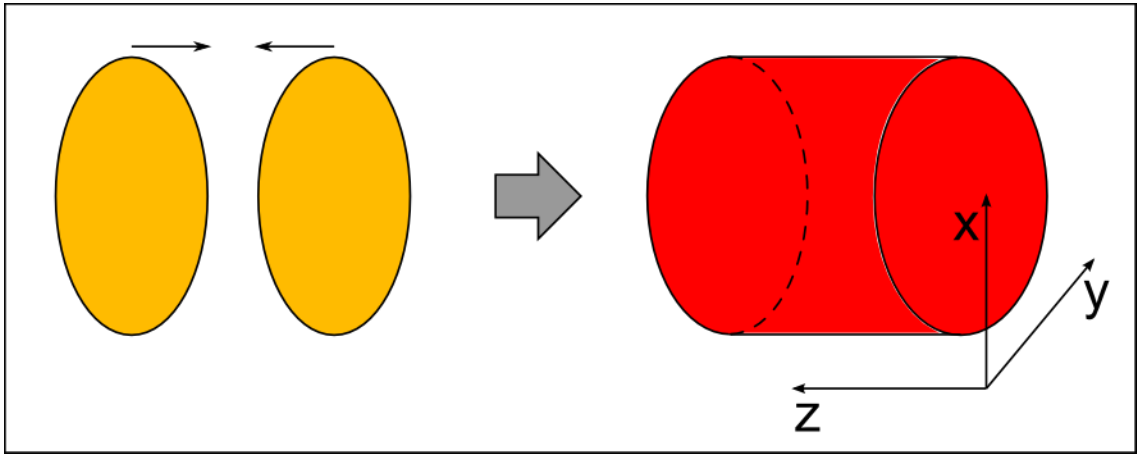
- At low energy, from the viewpoint of the theory lives on the D7 brane, X^8, X^9 are scalar fields, and scalar mesons in this picture are fluctuations of these fields.
- Dynamics of these fields are governed by DBI action of the D7 brane.
- there is an energy transfer in to the blackhole and fluctuations are damping.
- Energy of the mode is the mass of the Hadron.
- The life-time of the mode is the life-time (melting time) of the Hadron.
- The dual picture of Holographic Meson Melting.



Anisotropy

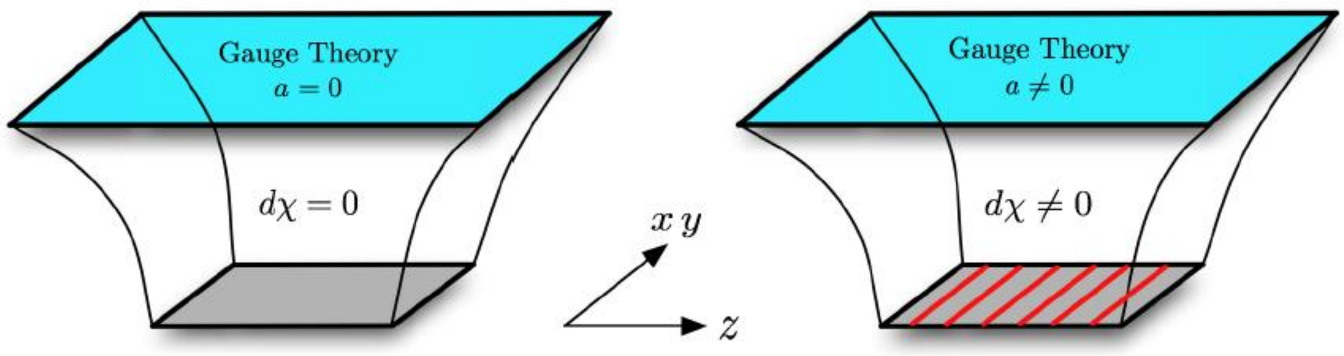
Anisotropy in Heavy Ion Collisions

At first moments after collision the system is highly anisotropic.



Anisotropic background solution

- We need an anisotropic background in Gravity (String) theory.
- There are different ways to make an anisotropic background in gravity.
- An anisotropic solution is found by T. Azeyanagi, W. Li and T. Takayanagi [arXiv:0905.0688] and generalized by D. Mateos, D. Trancanelli. [arXiv:1106.1637]
- The background is made by dissolving a set of D7 branes in the space.
- The solution is static and intrinsically anisotropic.



The picture is taken from paper by D. Mateos, D. Trancanelli. [arXiv:1106.1637]

Our Question

Our Question

We want to compute QN-modes of a D7 Flavor-Brane which is embedded in the space and Study the effect of anisotropy on the melting-time of the mesons.

$$ds^2 = \frac{1}{u^2}\left[-F(u)B(u)dt^2 + \frac{du^2}{F(u)} + H(u)dz^2 + dx^2 + dy^2\right] + e^{\phi/2}d\Omega_5^2$$

$$d\Omega_5^2 = d\theta^2 + \sin(\theta)^2 d\psi^2 + \cos(\theta)^2 d\Omega_3^2$$

$$F(u_h) = 0$$

$$A = \int d^8X \left[\det\left(G^{\mu\nu}\partial_\mu X^a \partial_\nu X^b\right)\right]^{1/2}$$

$$X(u,t) = X_0(u) + \delta X(u,t)$$

	R^4	u	S^3	S^2
D7	×	×	×	

$$\theta(u,t) = \theta_0(u) + \delta\theta(u)\, e^{i\omega t}$$

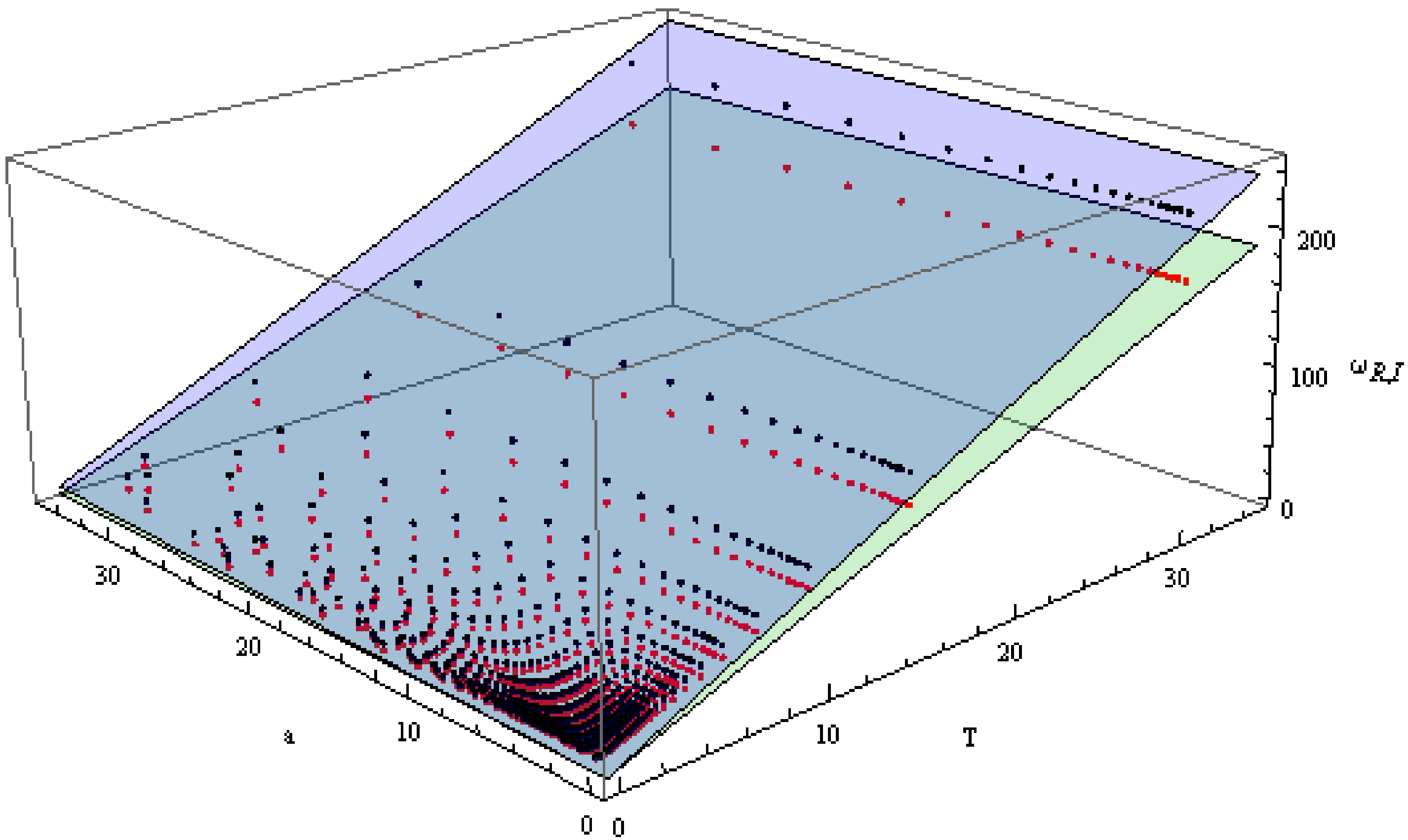
$$\theta_0(u) \approx m\, u + c\, u^3 + \ldots$$

$$\delta\theta(u) \approx \alpha\, u + \beta\, u^3 + \ldots \rightarrow \left\{\begin{array}{l} \alpha = 0 \\ ingoing\ \ at\ \ the\ \ horizon. \end{array}\right\} \rightarrow \textit{Just for special values of } \omega$$

Results

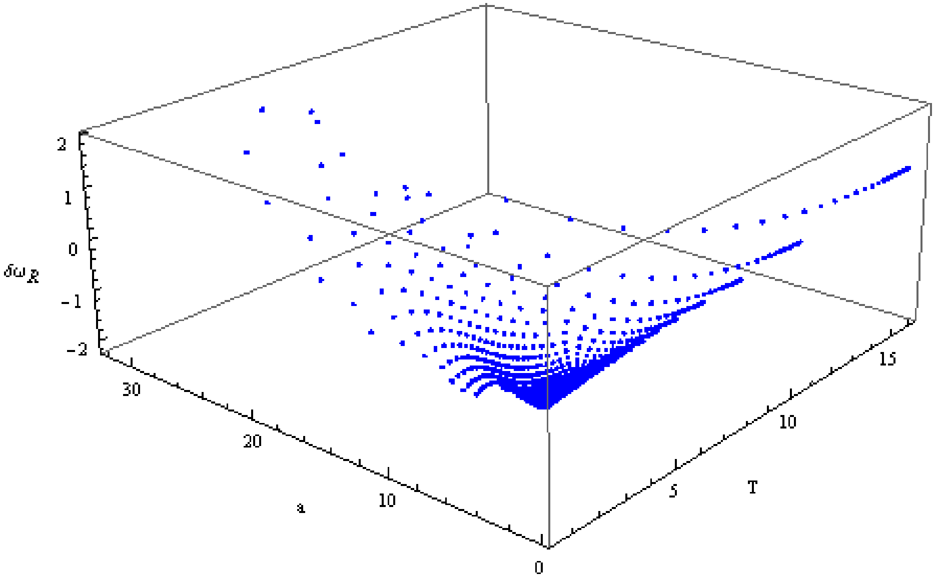
The modes are on a plane.

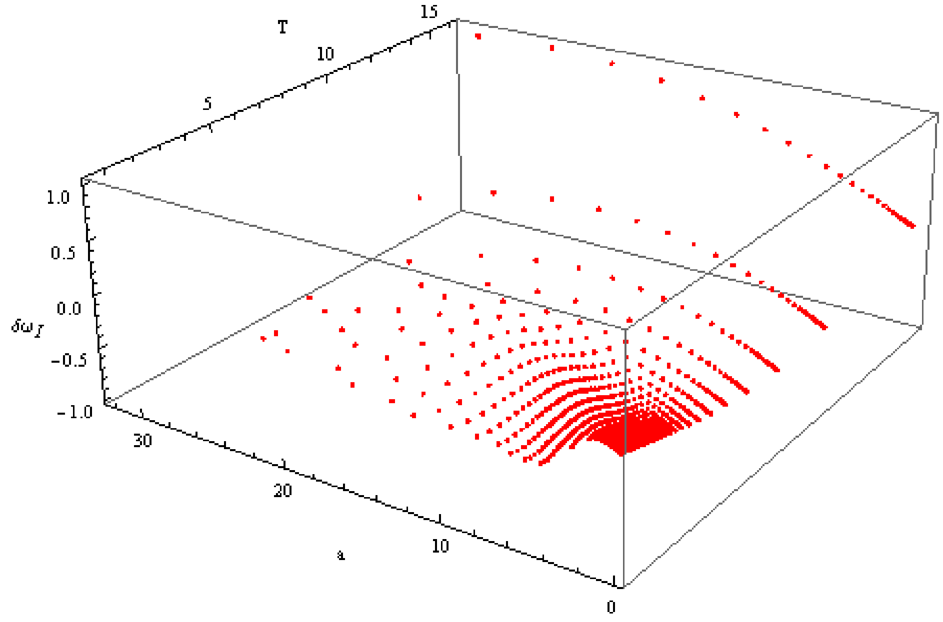
$$\omega_R = 6.88T + .22a \qquad \omega_I = 5.40T + .07a$$



Results

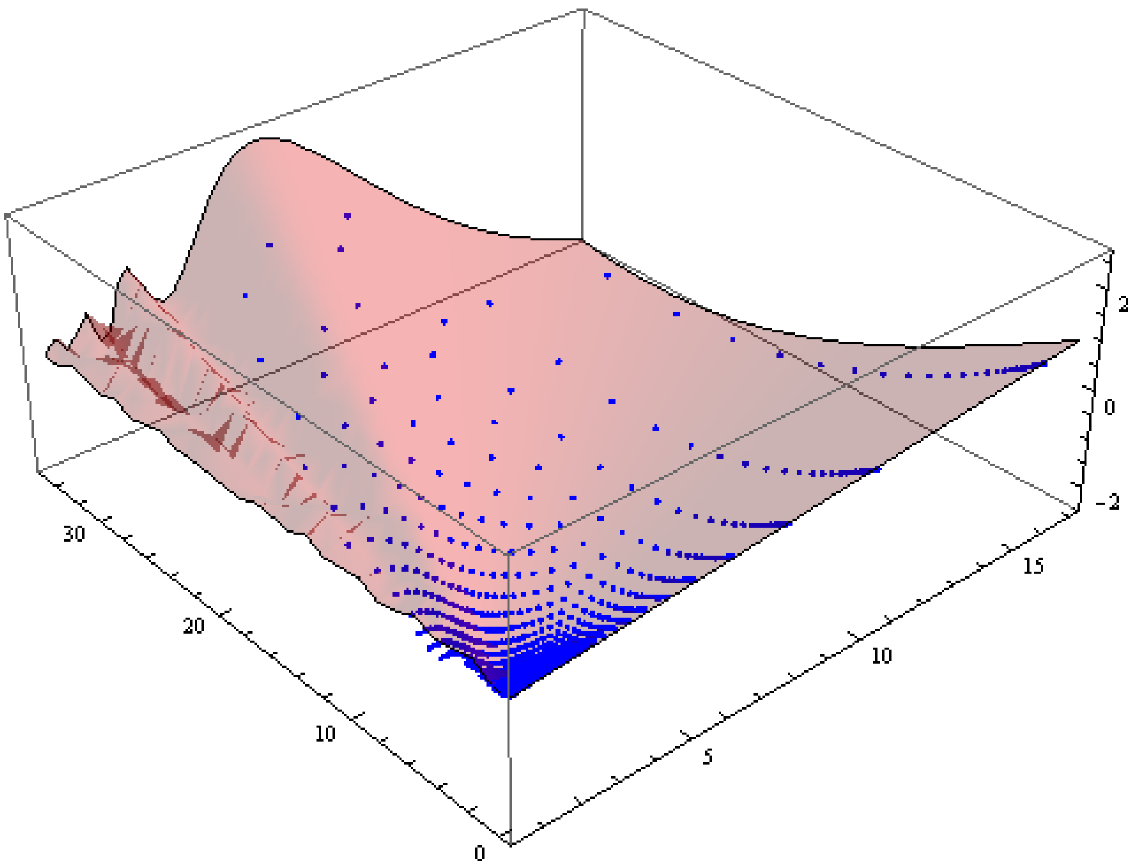
Deviations from the planes are wavy surfaces and seem to be the functions of a/T





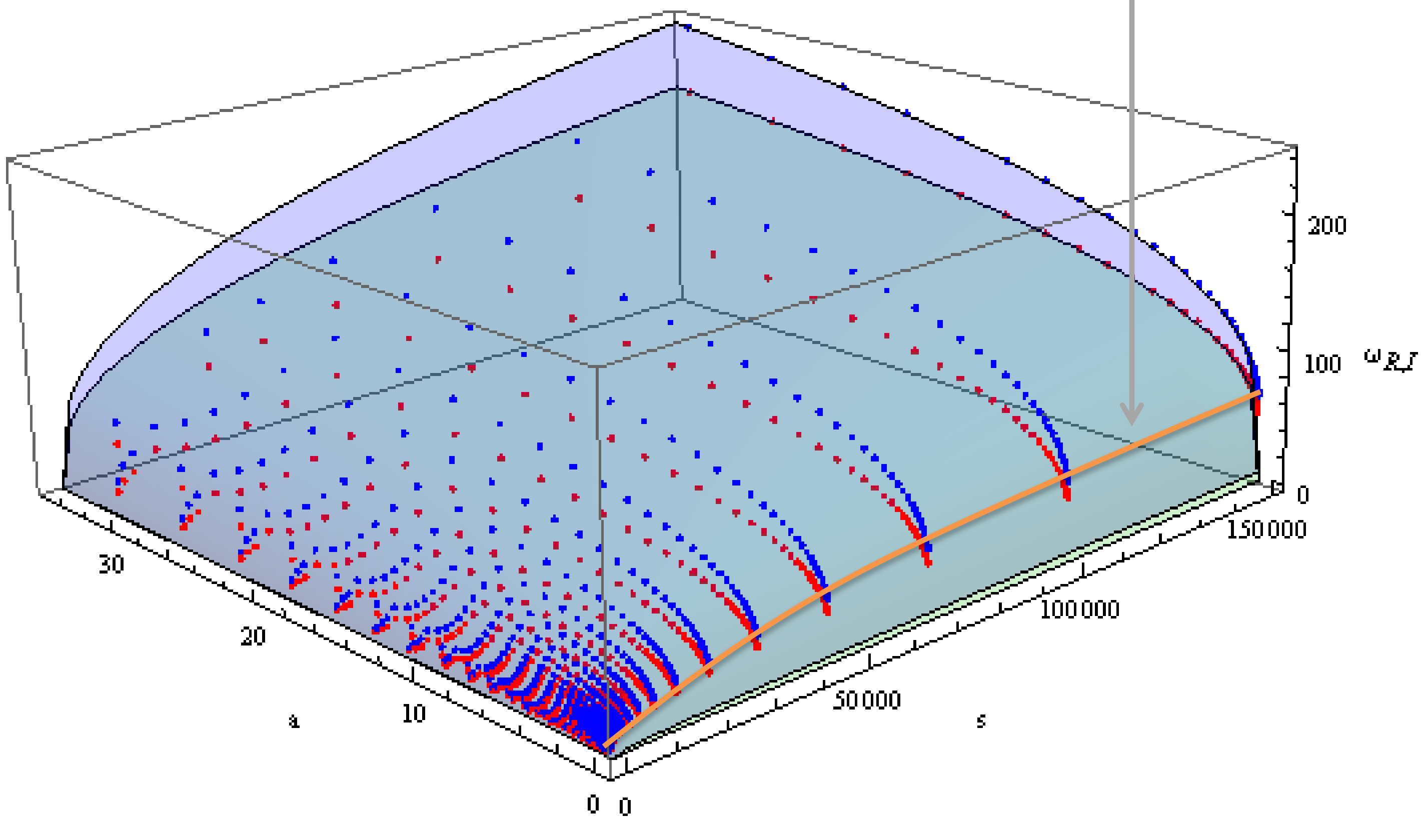
Results

$$\delta\omega_R = T\left(.16 - .1\,Cos(.35\frac{a}{T}) - .22\,Sin(.85\frac{a}{T})\right)$$



Thank You

Entropy Density



In isotropic case

$$\left\{\begin{matrix} s \propto T^3 \\ \omega \propto T \end{matrix}\right\} \rightarrow \omega \propto s^{1/3}$$

High temperature

$$\omega(a,T,m) = \omega_0(T,m) + \lambda(T,m)\ a^2$$