Quantum Signatures Of Chaos 3rd Edition

#Quantum Chaos #Signatures of Chaos #Quantum Physics #Chaos Theory #3rd Edition Physics Book

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Quantum Signatures Of Chaos 3rd Edition

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As Follows So Let's First Write the Minus L over Two Lambda a Squared Term that It Becomes Minus L Squared over 2 Times Integral T Lambda Rho of Lambda Times Lambda Squared this L Squared over Cancels the 1 over L and We Get a Factor of L and Then the Integral Picks off the Values Where the Delta Function Clicks and We Get the Sum of the Squares of the Eigenvalues Then We Should Write the Vandermonde Term and that's a It's Again L Squared because We Have a Double Sum So Now We Need To Cancel Two Factors of 1 over L
Then We Should Write the Vandermonde Term and that's a It's Again L Squared because We Have a Double Sum So Now We Need To Cancel Two Factors of 1 over L Times a Double Integral Okay So Now the Reason Why this Is a Heuristic Derivation and I Don't Know if There's Ai Don't Know if There's a Really Systematic Version of this the Reason It's a Little Bit Heuristic Is because the Measure That We'Re Supposed To Integrate Over in the Probability Distribution Is over Just It Is over Functions That Are Sums of Delta Functions
What We Do Is We Write Rho of Lambda Is Equal to Rho Semi-Circle of Lambda That's the Saddle Point plus a Small Correction Delta Rho of Lambda and Then We Look at the Action for this Fluctuation Delta Rho of Lambda That's Easy To Work Out the Linear of the Linear Variation Will Vanish and the Action for Delta Rho Will Just Come from this Second Term this Quadratic Term so We Find a Distribution for Delta Rho That's Proportional to Exponential of Minus L Squared Sorry Yeah Well We Start Out with plus L Squared Times this Expression Here That's a Little Bit Unpleasant because It's a by Local Expression and It's Convenient To Rewrite Delta Rho in Terms of a Fourier Transform Delta Rho of S
And Then We Fourier Transform that Expression To Go Back to Position Space eigen Value Space and We Find the Two-Point Function in this Ensemble Delta Rho of Lambda Delta Rho of Lambda Prime Is Proportional to There's a Minus Sign from the Fourier Transform of S 1 over L Squared and

Then the Fourier Transform Itself Is 1 over Lambda Minus Lambda Prime Squared So this Is the Fourier Transform of the Absolute Value of S Okay so We Find a Power-Law Correlation between these Eigenvalues so that's a Correlation That's Surprisingly Large at Long Distances between the Eigenvalues

So if You Have some Extra Density Here You'Re Likely To Have a Negative Fluctuation Somewhere Else and the Correlation Is Only Decaying like a Power of the Distance this Expression Breaks Down for Small Distances between the Eigenvalues in Particular for Distances That Are Close to the Typical Eigenvalue Spacing You Have To Use a More Accurate Formula Unfortunately I Don't Have Time To Derive that Formula It's a Famous Formula Called the Dyson's Sine Kernel and at Large Distances When the You'Re Considering the Correlator for Eigenvalue Seperation Is That Are Many Times the Basic Spacing between Eigenvalues Then this Is an Accurate Approximation so that Justifies this Sort of Heuristic Derivation

It's a Famous Formula Called the Dyson's Sine Kernel and at Large Distances When the You'Re Considering the Correlator for Eigenvalue Seperation Is That Are Many Times the Basic Spacing between Eigenvalues Then this Is an Accurate Approximation so that Justifies this Sort of Heuristic Derivation One Point about What this Means Is It's Sometimes Referred to as Diagnosing the Rigidity in the Spectrum of the Matrix Which Means that Fluctuations in the Density on Reasonably Large Scales Which Correspond To Smooth Functions with Small Values of the Fourier Variable S Are Strongly Suppressed because this Factor Becomes Large When S Is Small and that Strong Suppression Leads to this Power Law Anti-Correlation between the Eigenvalues

It's Sort of the Most It's Sort of the First Non-Trivial Result because It Is the First Thing That's Easy To See and the Perturbative Expansion about the Saddle Point about this Semi-Circle Saddle Point So if You Already Knew about the Semicircle Then this Is Sort of the Next Thing That You Should Understand the Small Fluctuations about It So Now We'Re Going To Turn to a Version of the Derivation Which Has Been Given that Exhibits this this Anti-Correlation Four of Eigenvalue Density this Is One of the Things That People Have Been Able To Establish for Semi-Classical Quantum Mechanical Systems Yeah Yeah that's Right the Spectrum Has a Tail and for Very Large It That's Actually an Interesting Subject All By

And this Would Be an Example of a Closed Path on this Bhalla Quotient and We Can Have Closed Geodesics and those Are Going To Be Important in the Discussion That Follows So There's a Formula Called the Selberg Trace Formula That Gives an Expression for Essentially an Expression for the Density of States of the Shortener Operator on this Space in Terms of a Sum over the Judith Appear like Geodesics Now before I Introduce the Selberg Trace Formula Let Me Mention a Simpler Problem That Will Hopefully Clarify Its Meaning

This Thing Is Equal to First Term Proportional to the Volume of the Hyperbolic Quotient Divided by Two Pi Times Sort of Times the Following Expression and Then We Have a Sum over Periodic Orbits So Periodic Classical Trajectories on this Hyperbolic Manifold of Actually the First Sum Is over What's Called Principle Periodic Orbits in Our Circle Example That Corresponds to an Orbit That Just Goes around the Circle once We'Ll Sum Separately over the Repetitions of that Orbit in a Second but Here We Consider a Sum over the Principle Orbits the Length over Squared of Beta Times Sum over M Okay so this Is the Formula and There's another Constantly Maracle Constant That Multiplies this Form the Second in Term Which I Haven't Written

Sorry Let Me Try To Finish I'Ll Discuss Questions Later if We Consider the Integral over Delta rho Then Its Action Looks like the Action for a Harmonic Oscillator to Quadratic Order in Row with a Frequency That's Given by L Times M over Beta That's Really Trivial To See What if You Plug this Expression into There I Wanted To Show You but I Don't Even Have To Like One Minute It Would Take So We Have a Harmonic Oscillator with that Frequency and It's Partition Function Is 1 Divided by Cinch of Beta Times Omega over 2 That's a General Formula for the Thermal Partition Function of a Harmonic Oscillator

That's Really Trivial To See What if You Plug this Expression into There I Wanted To Show You but I Don't Even Have To Like One Minute It Would Take So We Have a Harmonic Oscillator with that Frequency and It's Partition Function Is 1 Divided by Cinch of Beta Times Omega over 2 That's a General Formula for the Thermal Partition Function of a Harmonic Oscillator and that Gives Us this Factor the Frequency Is M Times L over Beta M Times L over Beta Divided by 2 Beta Gives this Expression

So in Other Words We Assume that the Partition Function Can Be Written as E of Beta Equals Integral over Energy of some Density of States of Energy with the Boltzmann Factor We Assume this and Then We Can Compute Rho V by Doing an Inverse Laplace Transform if We Do that Term by Term Here Then We Get an Expression a Formal Expression Which Looks like this or V Equals Putting this

in Quotes for Reasons That You'Ll See in a Second the First Term Gives Volume I Think It's a 4pi and Tan Ch Pi K so Here We'Re Going To Use Variables Where E Is Equal to One Half Times K Squared Plus 1 / 4
Because It's a Divergent Sum the First Term Here Gives a Reasonable Answer for Large Energies this Tench Is Approximately 1 They Give Something Proportional to the Volume the True Volume of Our Hyperbolic Quotient this Sum Here Is an Oscillating Sum because this Cosine Is an Oscillating Function of K and It Looks like the Sum Has a Good Chance To Be Convergent because of this Exponential Suppression the Denominator Here but in Fact the Sum Is Divergent It's Exponentially Divergent and a Nice Way To Show that Is as Follows We Can Compute the We Can Compute Say this Isn't a Sum over L this Is Sum over Orbits
That's Actually a Good Thing because the Density of States Is Supposed To Be a Sum of Delta Functions and this Looks like a Smooth Function so It Has To Be Able To Be Infinite in Places To Be a Sum of Delta Functions Okay Now One Point That's Well that Might Have some Kind of a Lesson for Thinking about Black Hole Physics Is that if We Look at the Partition Function the Formula for the Partition Function and We'Re at Reasonably High Energies so that Beta Is Small Then the Sum over these Orbits Gives Extremely Small Corrections to the Partition Function
I Don't Have Time To Write a Formula but Let Me Just Tell You It's a Very Short Derivation from this Point the Way It Works Is that You Write a Product of these Density of Energy Rho of E Times Rho of E Prime and You Forget the Smooth Term You Look at this some over these Oscillating Terms and You Look at the the Product of the Densities and You Integrate Over Let Me Write One Formula You Look at the Following Quantity Rho of Energy plus X over Two Times Rho of Energy minus X over Two and You Integrate this over Energy
And We Saw that It Was Easy To Compute Them In in Black Holes like Black Hole Physics Very Naturally Allowed Us To Compute these Diagnostics of Quantum Chaos but if We Really Think of Black Holes as Quantum Chaotic Objects Then They Should Also Have this Random Matrix Theory Behavior in the Spectrum so We Would Like To Have some Understanding of that from the Bulk or Well Maybe that's Too Specialized a More General Statement Is that We Would Like To Have a Understanding of this Random Matrix Theory Behavior for General Chaotic Systems if It's Such a Universal Property Then We Should Try To Find some Kind of a Universal Explanation
But if We Really Think of Black Holes as Quantum Chaotic Objects Then They Should Also Have this Random Matrix Theory Behavior in the Spectrum so We Would Like To Have some Understanding of that from the Bulk or Well Maybe that's Too Specialized a More General Statement Is that We Would Like To Have a Understanding of this Random Matrix Theory Behavior for General Chaotic Systems if It's Such a Universal Property Then We Should Try To Find some Kind of a Universal Explanation Ok So Let Me Stop There Thank You Very Much and I Apologize for Not Taking Questions during the Anthem
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