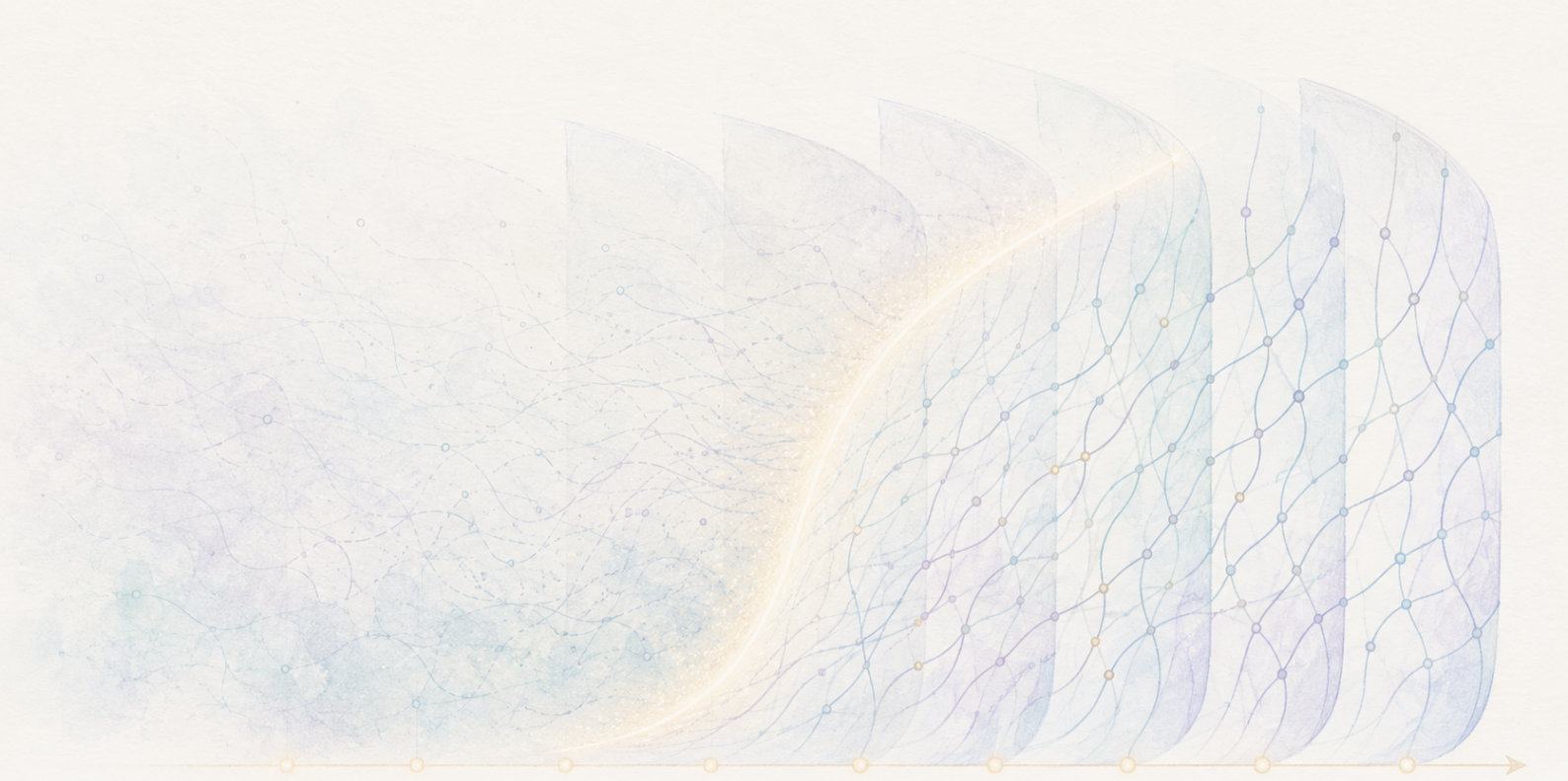

The Clean Paper

WHAT THE PAPER SAYS · WHAT IT DOESN'T · WHY IT MATTERS

Five-dimensional classical model yana ƙoƙarin sake gina quantum behaviour ba tare da quantizing gravity ba

Wata takarda a Scientific Reports ta gabatar da tsarin 4D + tau inda ordinary spacetime yake evolve karkashin wani ƙarin parameter. A simulations da model calculations, tsarin yana dawo da Newtonian gravity a equilibrium, yana nufin samun basic general-relativistic structure, kuma yana sake samar da EPR-type correlations da double-slit-like interference ta worldline dynamics. Wannan theoretical construction ne mai jan hankali, ba experimental proof cewa an warware quantum gravity ko cewa standard quantum mechanics kuskure ne ba.

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Hanyar classical zuwa quantum gravity babban ikirari ne. Wannan har yanzu samfuri ne

Yawancin ƙoƙarin haɗa quantum mechanics da gravity suna farawa ne da yunƙurin quantize gravity. Sabuwar takardar *Scientific Reports* ta Filip Strubbe ta gwada akasin haka: a bar tushen ka'idar classical, a ƙara wani parameter na evolution, sannan a tambaya ko familiar effects na gravity da wasu quantum phenomena za su iya fitowa daga wannan classical dynamics mafi faɗi.

Wannan mataki ne mai ƙalubale. Kuma yana da sauƙin wuce gona da iri wajen bayyana shi.

Takardar ba ta warware quantum gravity ba. Ba ta nuna cewa quantum mechanics kuskure ba ce. Ba ta soke Bell's theorem, kuma ba ta tabbatar cewa universe wata simple clockwork machine ce a ɓoye ba. Abin da take bayarwa shi ne **proposed classical framework mai dimensions biyar** wanda zai iya kwaikwayon wasu gravitational da quantum-like behaviours a cikin samfura, kuma yana yin wasu hasashe da za su iya bambanta da standard quantum theory.

Tambayar da ta fi amfani ba "classical physics ta kayar da quantum physics?" ba ce. Ba ta yi ba. Tambayar ta fi kunkuntar haka: **me classical theory za ta buƙaci ta ƙara ko ta saki domin ta kwaikwayi wasu abubuwan da ordinary four-dimensional classical physics ba za ta iya kwaikwaya ba?**

A wannan takardar, abin da aka ƙara ba fifth spatial dimension ba ne. Wani ƙarin parameter ne, mai suna **tau**, wanda a ƙarƙashinsa ordinary four-dimensional spacetime take evolve.

Ƙarin "lokaci" wanda ba ordinary time ba ne

Tsarin ya fara da ordinary four-dimensional spacetime: time coordinate ɗaya da space coordinates uku. Sannan ya ƙara wani external evolution parameter, tau. Coordinate time yana sanya events a cikin spacetime. Tau kuwa yana sarrafa yadda whole spacetime configuration take relax zuwa equilibrium.

Wannan bambanci shi ne ginshiƙin proposal ɗin. Takardar tana kiran tsarin **4D + tau**. A formal sense, five-dimensional ne, amma marubucin ya yi taka-tsantsan wajen ma'anarsa: babu five-dimensional metric da ta maye gurbin ordinary four-dimensional spacetime metric. Maimakon haka, tau parameter ne da ke motsa dynamics na four-dimensional geometry da worldlines na particles a cikinta.

Hoton da aka bayar ba na yau da kullum ba ne da gangan. Basic objects ba wavefunctions ba ne. **Worldlines** ne — hanyoyin da objects suke bi a spacetime — waɗanda za su iya canzawa yayin da tau ke canzawa. Takardar tana tunanin spacetime kamar tana "crystallize" a hankali a direction na time. Bayan crystallization front, configurations sun relax zuwa stable outcomes; a gabansa kuma future ba ta riga ta tsara kanta haka ba.

Ga observer a cikin tsarin, outcomes da suka kai equilibrium ne kawai za a iya gani. Observer ba ya ganin tau kai tsaye. Yana sake gina ordinary four-dimensional history daga jerin outcomes da suka "crystallize."

Haka takardar take ƙoƙarin samun abubuwa biyu tare: underlying dynamics mai ƙayyadadden classical evolution, da kuma bayyanar ordinary time, measurement outcomes da quantum-like behaviour daga cikin tsarin.

Da farko gravity: Newton, sannan wasu sassan Einstein

Ɓangaren gravity ya fara a weak-gravity limit. Marubucin ya rubuta relaxation equation ga gravitational potential. Idan tsarin ya kai equilibrium game da tau, equation ɗin yana komawa ordinary Newtonian Poisson equation na gravity.

Takardar ta kuma ba worldlines relaxation rule nasu. A equilibrium, worldlines suna motsawa zuwa hanyoyin da Newtonian gravity take tsammani. Numerical examples ɗin an yi su masu sauƙi da gangan: misali static mass guda da system na masses biyu suna relax zuwa Newtonian spacetime.

Sannan marubucin ya faɗaɗa wannan ra'ayi zuwa general relativity. Maimakon gravitational potential kaɗai ya relax, spacetime metric kanta take relax. A equilibrium, worldlines suna zama **geodesics**: hanyoyin da objects masu free fall suke bi idan gravity ce kaɗai force da ke aiki, wato kwatankwacin straight lines a curved spacetime. Ana nufin geometry ta dawo da wasu basic features na general relativity.

Amma iyakar ikirarin tana da muhimmanci. Takardar ba cikakkiyar derivation ce ta duk strong-field predictions na general relativity ba. Ta bar strong-field regimes, singularities, gravitational redshift, gravitational waves da richer worldline behaviour ga future work. Ikirarin shi ne framework ɗin yana iya dawo da Newtonian gravity a weak limit da basic general-relativistic structure a smoother setting — ba cewa ya maye gurbin duk tested machinery na Einstein gravity ba.

Matakin Bell test: canza assumption na spacetime

Mafi wahalar ɓangare ga duk classical account na quantum mechanics shi ne nonlocality.

Bell's theorem tana gaya mana cewa, ƙarƙashin standard assumptions, babu **local hidden-variable model** da zai iya reproduce duk quantum correlations. Gwaje-gwaje sun karya Bell inequalities sau da yawa. Saboda haka ordinary four-dimensional classical pictures ba su isa ba.

> **Bell inequalities cikin harshen yau da kullum**
>
> Ka yi tunanin particles biyu sun fito daga source ɗaya suna ɗauke da "hidden instructions." A wurare masu nisa, Alice da Bob kowannensu ya zaɓi yadda zai auna particle ɗinsa. Idan sakamakon kowane bangare ya riga ya ƙayyadu da local instructions nasa, babu bangare da choice na ɗayan zai shafa, kuma measurement settings ba su da statistical relation da waɗannan instructions, Bell inequalities suna saka iyaka ga yadda sakamakon bangarorin biyu zai iya yin correlation. Real experiments sun wuce wannan iyaka. Abin da hakan ke nufi ba cewa wani alternative guda ya ci nasara ba ne, sai dai cewa realism, locality da statistical independence ba za a iya riƙe su duka tare ba.
> Don derivation mataki-mataki na local bound, quantum prediction da experimental tests, duba jagorarmu kan Bell's theorem.

Amsar takardar ba ita ce ta musanta Bell's theorem ba. Tana **canza setting** inda theorem ɗin ake amfani da ita. A 4D + tau framework, influences za su iya yaduwa a worldlines yayin da configuration take evolve a tau. Idan ana kallon ordinary spacetime kaɗai, wannan zai iya bayyana kamar nonlocal correlation. Amma daga viewpoint na

proposed underlying dynamics, interaction ɗin local ne along relevant worldlines a tau.

Takardar ta gina model na EPR-type experiment da photons biyu da Alice da Bob suke aunawa. Samfurin ya reproduce standard quantum correlations ga maximally entangled polarization state. Amma farashin formal ɗin a fili yake: samfurin ya **saki statistical independence gaba ɗaya**, inda measurement na Alice yake precondition state na Bob ta tau dynamics. Mechanism ɗin ba standard quantum collapse ba ne; tau-driven relaxation ne na polarization states along connected worldlines.

> **Abin da Alice da Bob suke kwatantawa a zahiri**
>
> Source yana aika photon ɗaya ga Alice da partner ɗinsa ga Bob. Kowannensu yana amfani da polarizing beam splitter a angle da ya zaɓa sannan ya rubuta ɗaya daga outcomes biyu: wucewa ko karkatawa. Pair guda ba zai nuna correlation ba. Gwajin yana fitowa ne daga maimaita wannan sau da yawa, sannan a kwatanta yadda outcomes suke dacewa yayin da angle tsakanin splitters ya canza. Quantum theory tana hango correlations da suka fi abin da local, statistically independent hidden instructions za su yarda da shi. A samfurin Strubbe, measurement na Alice yana faruwa first in tau; polarization relaxation sannan yana propagate along connected worldlines, ya koma ta common source ɗinsu sannan ya bi path na Bob. Saboda haka state na Bob ta riga ta conditioned lokacin da ya yi measurement. Wannan yana reproduce correlation a cikin samfurin, amma ta hanyar canza causal setting da barin statistical independence.

Wannan ɓangaren yana buƙatar iyaka mafi ƙarfi. Reproduce EPR-type model guda a wani proposed framework ba daidai yake da derive duk quantum theory daga classical mechanics ba. Takardar kanta ta lura cewa deviations daga standard quantum predictions na iya bayyana idan information transfer along worldlines ya yi jinkiri sosai, ko kuma idan spatial separations suka yi girma har measurement ɗaya ya kammala kafin outcome information da ya dace ya propagate a tau.

Wannan **hanyar gwaji ce**, ba zagayen murna ba.

Double slit, an sake gina shi da worldlines masu motsi

Misalin quantum na biyu shi ne double-slit interference.

Takardar tana wakiltar massive particle — neutron a nan — a matsayin **bundle na worldlines**, ba classical point guda ko standard quantum wavefunction ba. A misalin, neutron yana da de Broglie wavelength 2 nm da velocity 2,000 m/s. Slit width da aka kwaikwaya 10 nm ne, slit separation kuma 25 nm, ƙanana fiye da typical neutron-interference experiments domin pattern ya fi fitowa a hoto.

Bundle na worldlines yana evolve ƙarƙashin wani entropic rule. Density na endpoints na worldlines yana samar da interference-like distribution, yayin da wani worldline da aka zaɓa, **momentum worldline**, yake ɗaukar energy da momentum kuma yake ƙayyade actual detection event. Wannan ita ce hanyar takardar ta raba wave-like behaviour daga particle-like outcome ba tare da intrinsic quantum superposition ba.

Sannan takardar ta tambayi abin da gravity za ta bayyana. A kowane simulated neutron, worldlines da yawa suna taimakawa wajen gina interference-like density, amma selected momentum worldline kaɗai ne yake ɗaukar energy

da momentum kuma ya zama source na gravity. Samfurin yana sanya idealized gravitational probe guda a tsakiyar slits da guda biyu a hagu da dama. Idan momentum worldline ya wuce right slit maimakon left slit, tiny gravitational response zai karkata tare da shi. Idan za a iya karanta wannan asymmetry, za a san wace slit aka bi, yayin da full bundle na worldlines har yanzu zai gina interference pattern a screen. Kiyasin acceleration signal kusan $2 \times 10^{-23}\,\mathrm{m\,s^{-2}}$ ne, kuma takardar ta ajiye practical measurement limitations a gefe.

Wannan lamba tana da muhimmanci domin tana hana wuce gona da iri. Proposal ɗin **ba** cewa an riga an auna gravitational which-way information ba ne ba tare da lalata interference ba. Abin da yake cewa shi ne, a wannan samfurin, irin wannan information ya kamata a principle a iya samu saboda gravitational field tana da alaƙa da definite worldline guda, ba superposition na paths biyu ba.

Wannan ya saba kai tsaye da standard quantum expectation cewa which-way information tana lalata interference. Saboda haka yana ba framework ɗin wani yiwuwar wurin gwaji a empirical level.

Abin da wannan binciken bai tabbatar ba

- Bai tabbatar cewa an warware quantum gravity ba.
- Bai tabbatar cewa gravity classical ce a nature ba.
- Bai soke Bell's theorem ba; ya canza spacetime-causality setting kuma ya saki statistical independence a cikin samfurin.
- Bai reproduce duk quantum mechanics ba. Takardar tana model selected phenomena kuma ta bar full quantum formalism ga future work.
- Bai nuna cewa an dawo da general relativity gaba ɗaya a strong-field regimes ba.
- Bai sa wavefunctions, Hilbert spaces, complex numbers ko quantum field theory su zama marasa amfani ba.
- Bai bayar da experimental confirmation ba. Aikin theoretical ne kuma ya dogara da simulations.

Iyaka mai sauƙi ita ce: **takardar tana gabatar da higher-dimensional classical framework da zai iya kwaikwayon wasu halaye masu wahala. Ba ta nuna cewa nature tana amfani da framework ɗin ba.**

Me zai sa a iya gwada shi?

Ɗaya daga cikin mafi ƙimar sassan takardar shi ne ba ta tsaya a philosophy kawai ba. Tana nuna wuraren da framework ɗin zai iya bambanta da standard quantum theory.

Hasashe na farko yana shafar EPR-type experiments. Idan tau-mediated information transfer along worldlines ba effectively instantaneous ba ce idan aka kwatanta da crystallization process, to setups masu nisa sosai ko measurements masu sauri na iya nuna deviations daga quantum correlations da aka saba gani.

Hasashe na biyu yana shafar double-slit experiments da massive particles. Samfurin yana cewa a principle za a iya fitar da **gravitational which-way information** ba tare da kashe interference pattern ba. Wannan babban bambanci ne da standard quantum reasoning, ko da kuwa signal ɗin da aka hango yana da matuƙar ƙaranci kuma ba a nuna practical feasibility ba.

Hasashe na uku yana shafar proposals da suke gwada ko gravity za ta iya mediate entanglement tsakanin masses. Yawancin current quantum-gravity test proposals suna ɗaukar gravitationally mediated entanglement a matsayin alamar cewa gravity tana da quantum features. A framework na Strubbe, gravitational field tana assigned zuwa definite worldline guda, don haka irin wannan gravitationally induced entanglement **bai kamata ya faru ba**.

Waɗannan ba ƙananan bambance-bambance ba ne. Su ne irin differences da speculative framework take buƙata idan tana son ta zama fiye da interpretation kawai.

Yaya ƙarfin shaidar yake?

Shaidar ta fi ƙarfi a matsayin **nuna internal consistency**.

Takardar ta gabatar da equations, simulations da examples da ke nuna yadda 4D + tau machinery ɗinta zai iya dawo da Newtonian gravity a equilibrium, matsawa zuwa basic general-relativistic structure, reproduce EPR correlation model, da samar da double-slit-like interference pattern ga massive particle.

Amma shaidar **ba ta kai matsayin hujja mai ƙarfi game da duniya ba tukuna**.

Demonstrations ɗin an zaɓe su ne. Framework ɗin bai kai full quantum formalism ba. Strong-gravity cases ba a warware su ba. Proposed experimental deviations ba a gani ba. Data-availability statement ta ce datasets da aka samar da nazari a binciken ana iya samu daga corresponding author idan an nema da dalili, amma core claim ba sabon measurement ba ne; theoretical construction ne.

Wannan ba flaw ba ne da kansa. Sabbin frameworks sukan fara da construction. Amma karatu mai tsabta ya kamata ya ware **construction, simulation, prediction da confirmation** a kwalaye dabam.

Me ya sa wannan yake da muhimmanci

Takardun foundations suna iya yin sauti mai girma saboda kalmominsu suna da girma: quantum gravity, nonlocality, time, realism, determinism. Haɗarin shi ne headline ta fi sakamakon girma.

Wannan takardar tana da darajar karantawa domin tana kai hari ga wani pressure point na gaske. Standard quantum theory da general relativity ba sa haɗuwa da sauƙi. Bell-type correlations sun karya ordinary local classical explanations a standard spacetime. Measurement da time har yanzu suna da matsalolin conceptual. Framework da ke cewa “watakila assumption na spacetime ne ya kamata mu fara canzawa” ba ta zama daidai kai tsaye ba, amma tambayar da take yi tana da inganci.

Matakin da ya fi ban sha’awa ba nostalgia ga tsohon classical physics ba ne. Shi ne **farashin** sa classical picture ta yi aiki: ordinary spacetime causality ba ita kaɗai ce causal arena ba. Framework ɗin yana sayen realism da determinism ne ta ƙara tau-dynamics da observers ba za su iya ganin kai tsaye ba.

Ko wannan farashin ya dace tambayar physics ce, ba slogan ba. Predictions na takardar su ne inda ya kamata a gwada ta.

Takaitaccen bayani

Filip Strubbe ya gabatar da classical framework mai dimensions biyar inda ordinary four-dimensional spacetime take evolve ƙarƙashin ƙarin parameter, **tau**. A equilibrium, framework ɗin yana dawo da Newtonian gravity a weak-gravity limit kuma yana nufin dawo da basic general-relativistic structure fiye da haka. Ya kuma model quantum phenomena biyu: EPR-type correlations ta influences da ke propagate along worldlines a tau, da double-slit interference ta bundle na worldlines wanda density ɗinsa ke yin wave-like behaviour yayin da momentum worldline guda yake ƙayyade outcome. Proposal ɗin theoretical ne kuma ya dogara da simulation. Muhimmancinsa ba cewa ya warware quantum gravity ba ne, sai cewa ya gina concrete classical alternative da wasu yiwuwar experimental differences, ciki har da gravitational which-way information da rashin tsammanin wasu gravity-mediated entanglement tests su ba da quantum entanglement.

Bincike ba tare da ƙarin gishiri ba

Abin da takardar ta nuna: Proposed 4D + tau classical framework na iya reproduce selected gravitational da quantum-like behaviours a samfura: Newtonian gravity a equilibrium, basic general-relativistic structure, EPR-type correlations da double-slit-like interference.

Abin da yake yiwuwa amma ba a tabbatar ba: Framework ɗin zai iya zama wata hanyar gaske zuwa quantum gravity. Takardar tana ba da route da predictions; ba ta tabbatar cewa nature tana bi ba.

Abin da bai nuna ba: Bai warware quantum gravity, soke quantum mechanics, soke Bell's theorem, ko tabbatar ta experiment cewa gravity classical ce ba. Haka kuma bai bayar da complete replacement ga full quantum formalism ba.

Babban iyaka ga mai karatu na gama gari: Muhimmin matakin takardar shi ne ƙara tau-dynamics a wajen ordinary spacetime. Wannan na iya zama physically fruitful, amma assumption ɗin ne yake ɗaukar babban ƙangaren aikin. Kada a haɗa "classical a cikin framework mafi faɗi" da "ordinary classical physics ta kasance daidai tun farko."

Yawan amincewar da ya dace ga mai karatu na gama gari: Matsakaici cewa takardar tana gabatar da serious, explicit theoretical construction; ƙasa cewa ita ce amsa ta ƙarshe. Abin da ya dace a ɗauka ba imani ko watsi ba ne, sai tambaya mafi kaifi: **za a iya mayar da proposed deviations ɗinta daga standard quantum theory zuwa gwaje-gwajen da za a iya yi kuwa?**

Majiyoyi

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