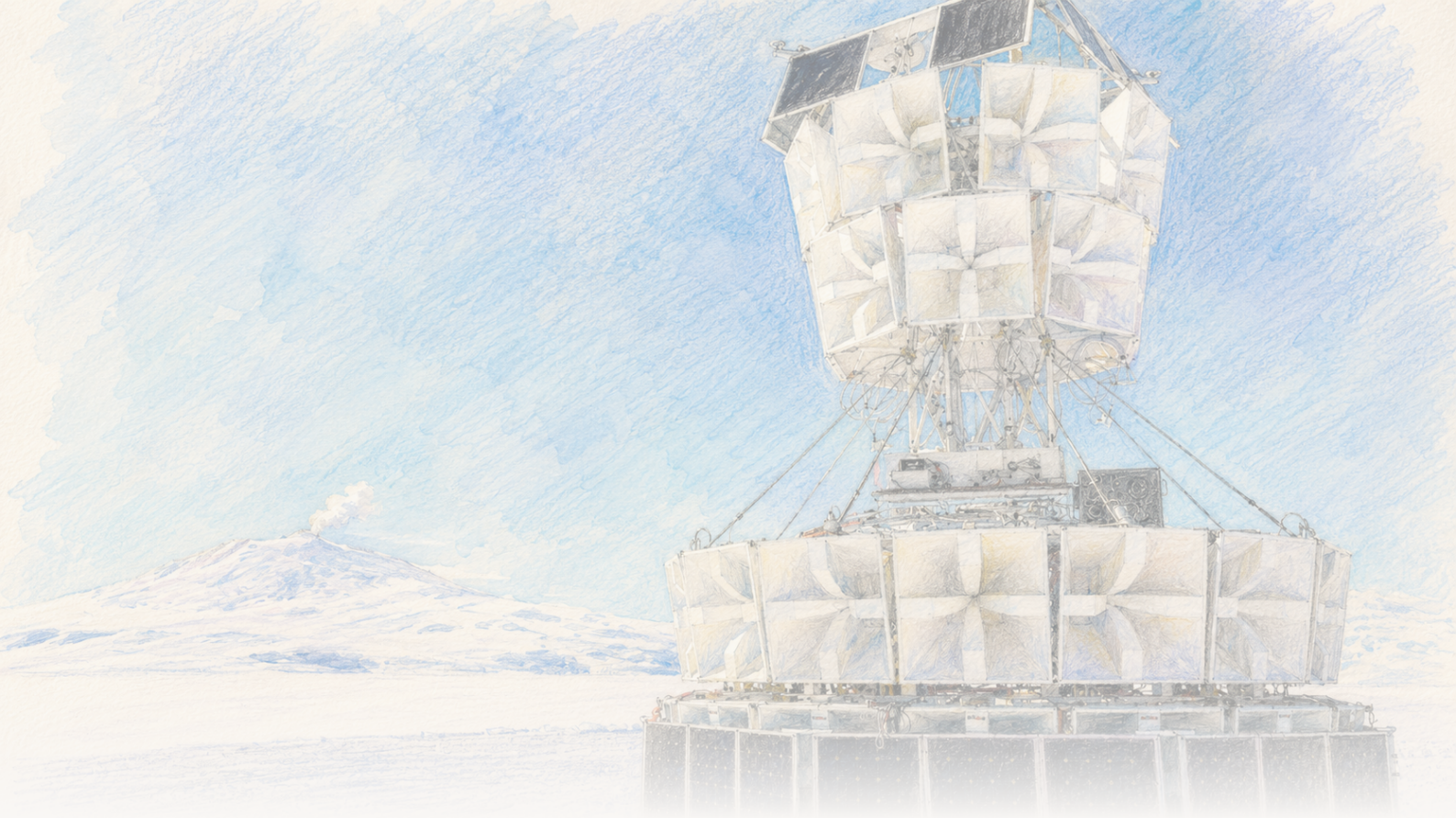


The Clean Paper

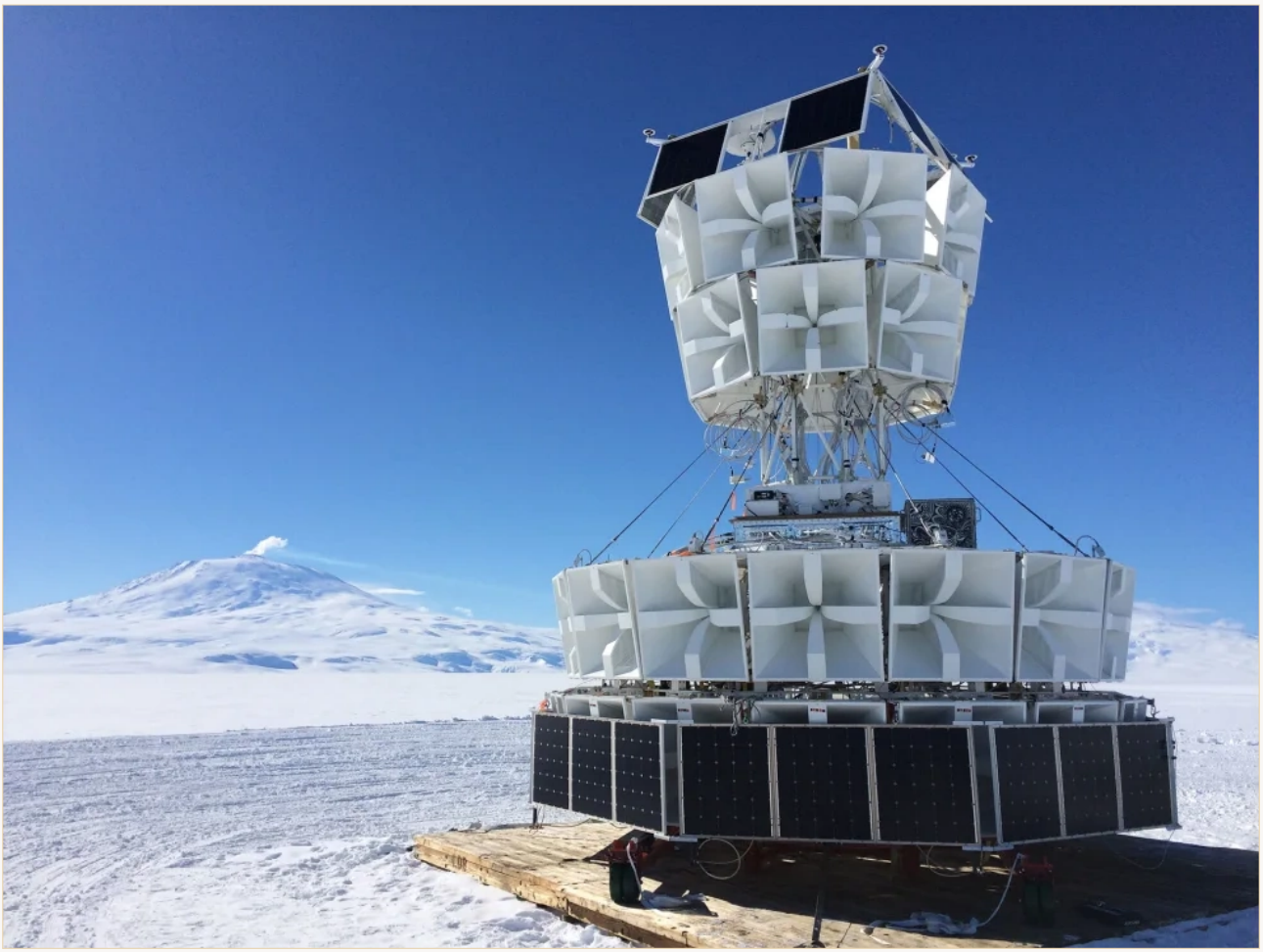
WHAT THE PAPER SAYS · WHAT IT DOESN'T · WHY IT MATTERS

Bugun rediyo biyu na ban mamaki a saman Antarctica har yanzu ba a bayyana su ba — kuma bayanin “sabon barbashi” yana rasa goyon baya

Bugun rediyo biyu da wani gwajin balon Antarctica ya rubuta shekaru da suka wuce har yanzu ba su da bayanin da aka amince da shi; wani bincike na musamman na Pierre Auger bai ga alamar ruwan barbashin da ya kamata su haifar ba, yana rage yiwuwar fassarar “sabon barbashi” sosai yayin da matsalar kanta ba ta warware ba.

Written by Lucio Vaglio · Cross-checked by Laura Nesso · Edited by Michele Renda · Figures by Laura Nesso · AI-assisted, human-reviewed

Paper: *Search for the Anomalous Events Detected by ANITA Using the Pierre Auger Observatory*, Pierre Auger Collaboration, Physical Review Letters 134, 121003 (2025) · DOI: 10.1103/PhysRevLett.134.121003



Anternoni 48 na ANITA suna kallon ƙasan kankarar Antarctica daga gondola mai tsawon ƙafa 25.

Christian Miki / University of Hawai'i at Mānoa fair-use assertion

Balon, kankara, da bugun sigina biyu daga ƙasa

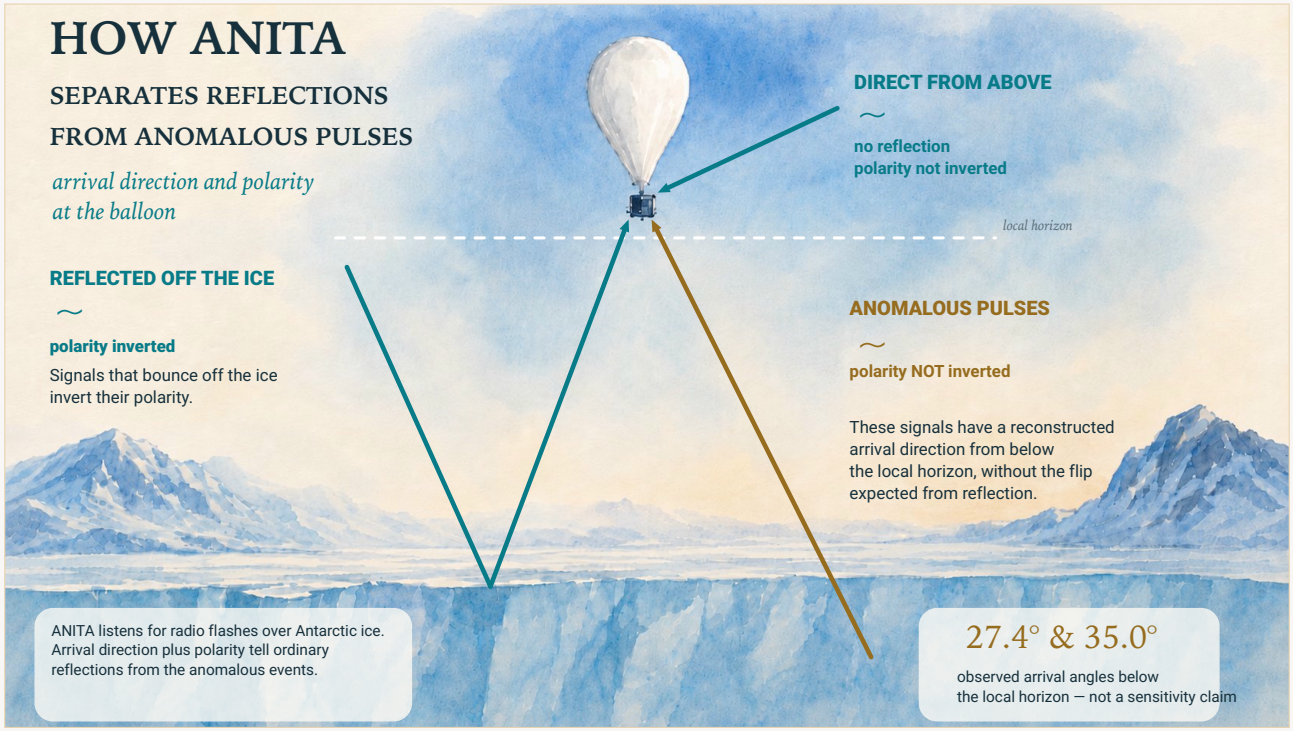
A mafi yawan lokacin aikinsa, Antarctic Impulsive Transient Antenna — ANITA — yana rataye a ƙarƙashin balon NASA, kusan kilomita talatin sama, yana shawagi tsawon makonni a kan wuri mafi ƙarancin mutane a Duniya, yana sauraro.

Abin da yake saurara shi ne siginar rediyo daga sararin samaniya. Idan barbashi mai matuƙar ƙarfi — cosmic ray ko neutrino — ya bugi iska ko kankara, yakan watse ya zama ruwan ƙananan barbashi, sannan wannan ruwan barbashi ya fitar da ɗan walƙiyar rediyo na ɗan lokaci. Antarctica ta kusan zama wuri mafi dacewa don kama su: akwai kilomitoci na kankara mai tsabta da sanyi da rediyo ke ratsa wa kamar gilashi, kuma babu wani abu na ɗaruruwan kilomitoci da zai rikita siginar. Aikin ANITA shi ne kama walƙiyar sannan ya karanta daga siffarta da lokacinta abin da ya haifar da ita.

Yawancin abin da yake ji yana bin abin da ake tsammani. Wasu walƙiya suna zuwa kai tsaye daga sama. Da yawa kuma sukan bugi kankara su dawo sama zuwa antena — kuma suna

ɗauke da alamar da take bayyana su: bugawar kan kankara tana juya igiyar rediyo akasin yadda take (juyawar *polarity* na sigina), wata alama da masana kimiyyar lissafi ke gane wa nan take. Haka ake bambanta siginar da ta dawo daga wadda ta zo kai tsaye.

Sau biyu, wani abu ya zo wanda bai bi wannan tsarin ba.



A wurin balon, bugun sigina da ya zo kai tsaye daga sama yana isa ba tare da an juya shi ba, yayin da wanda ya dawo daga kankara yake isa polarity ɗinsa a juye — alamar da aka saba gani idan ya bugi kankara. Amma bugun sigina biyu na ban mamaki sun zo daga alkiblar da aka *sake lissafawa* mai zurfi a ƙarƙashin sararin ganin wurin — ba tare da wannan juyawar ba, alhali komawa daga kankara ya kamata ya juya su. “Daga ƙasa” yana nufin alkiblar zuwan da aka lissafa — ba barbashi da ya haura daga cikin Duniya ba.

A wani jirgi a 2006 da wani a 2014, ANITA ya kama bugun sigina daga ƙasa sosai da sararin gani — 27.4° da 35.0° a ƙarƙashinsa, bi da bi — kamar ya fito daga nahiyar ya hau sama, ba tare da *juyawa* ba. Don haka ba komawar sigina daga kankara ba ce. Ya zama kamar wani abu ne da gaske ya yi tafiya sama, daga kankara zuwa balon.

Ga dalilin da ya sa wannan ya kusan karya abin da aka sani. Don ya kai antena da irin wannan gangaren hawa, duk abin da ya haifar da bugun siginar sai ya ratsa cikin duniyar nan — kilomita dubu shida ko bakwai na dutse mai kauri. Kusan babu abin da zai iya yin haka. Barbashi ɗaya da aka sani yana ratsa abu na yau da kullum kamar babu shi shi ne neutrino, wanda zai iya ratsa Duniya gaba ɗaya ba tare da ya bugi kome ba. Saboda haka tunanin farko shi ne neutrino ya haura cikin dutsen, ya bugi atom kusa da ƙarƙashin kankara, ya samar da ruwan barbashi masu gudu sama, sannan ANITA ya kama walƙiyar rediyonsu. Amma akwai matsala: neutrino mai ƙarfin da zai iya samar da *wannan* sigina a zahiri yana da sauƙin tsayawa. A cikin dutsen mai yawa haka, ya kamata a sha shi sau da dama. Kuma kwararar neutrino mai ƙarfi da har biyu suka iya tsallakewa ya kamata ta bayyana a manyan na’urorin

da aka gina musamman domin kamawa. Babu wata sauƙaƙƙiyar bayani da ta rufe batun gaba ɗaya.

Saboda haka bugun sigina biyun suka ci gaba da zama, ba su bi abin da ake tsammani ba. Ba gano sabon abu ba ne — abubuwa biyu ba za su taɓa zama cikakkiyar ganowa ba — amma ba banza ba ne. Matsala ce ta gaske: irin wadda take da ban sha'awa saboda babu wanda ya iya cewa ko wata kafa ce a Standard Model na kimiyyar lissafi, ko kuma wani yanayi ne na kankara, antena, ko lissafi.

A nan ne wasu labarai sukan ɗauko kalmar *asiri*, su rage haske, su tambayi abin da zai iya rayuwa a ƙarƙashin Antarctica. Kada mu bi su. Tambayar gaskiya ba ta taɓa zama *wace halitta ce take cikin kankara ba.* Tambayar mai haƙuri ce, wadda ba ta da kwalliya amma ita ce ke ciyar da kimiyya gaba: **ta yaya za ka gano?**

Abin da marubutan suka yi

Akwai hanya mai tsabta ta gwada bayanan da suka fi jan hankali. Idan bugun siginar ANITA sun fito ne daga ainihin kwarara mai maimaituwa na ruwan barbashi masu hawa sama — ko daga tau-neutrino na yau da kullum ko daga wani sabon barbashi da aka gabatar — to babban na'urar ganowa da ke kallon irin waɗannan abubuwa ya kamata ya kama wasu daga cikinsu.

Pierre Auger Observatory a Argentina — na'urar gano cosmic ray mafi girma da aka taɓa ginawa — tana da wurin da ya dace da binciken. Ta amfani da Fluorescence Detector, ƙungiyar ta nemi ruwan barbashi na iska masu hawa sama (masu zuwa daga ƙasa, a kusurwar zenith sama da 110° da makamashi sama da 0.1 EeV) a bayanan daga 2004 zuwa 2018. Muhimmin abu shi ne an tsayar da duk ka'idojin zaɓe *kafin* a duba cikakken bayanan — bincike "makaho," domin kada a sarrafa amsar zuwa abin da ake son samu.

Abin da suka gano

Bayan buɗe bayanan, abin da ake zargi **guda ɗaya** ne kawai ya rage — kuma ya yi daidai da abubuwa **0.27** ± **0.12** da ake tsammani daga cosmic rays na yau da kullum da a wasu lokuta ake kuskuren lissafa su a matsayin masu hawa sama. Wato babu ainihin siginar da ke hawa sama; sai ɗan bayan fage da ake tsammani.

Karfin sakamakon yana cikin kwatancin. Idan bugun ANITA sun fito ne daga dawwamammen kwararar ruwan barbashi masu hawa sama, Auger ya kamata ya rubuta **da yawa** — kusan 34 zuwa 69 a wani yiwuwar rabon makamashi, kuma aƙalla kusan 8 ko da an yi amfani da zato mai matuƙar taka-tsantsan. Ya sami guda ɗaya, wanda ya yi daidai da bayan fage. Marubutan sun kira wannan "saɓani mai ƙarfi" da fassarar ruwan barbashi masu hawa sama.

Abin da wannan mai yiwuwa yake nufi

Rashin gano abu a wannan mataki yana bayar da bayani. Idan abubuwan ANITA sun fito ne daga ainihin rukunin barbashi da ke zuwa daga waɗannan alkibla — tau-neutrino na yau da kullum ko sabbin barbashi na zato da aka gabatar domin bayyana su — dogon lokacin kallon Auger ya kamata ya kama adadi mai yawa. Bai kama ba. Wannan kusan yana kawar da bayanin “kwararar ruwan barbashi masu hawa sama da ta bazu” — rukunin da yawancin tunanin da suka wuce Standard Model suke ciki — sai dai idan an ƙirƙiri wasu sharuɗɗa na musamman sosai.

Abin da ya rage shi ne bayanan da *ba* kwararar barbashi masu samar da ruwa ba ne: mafi yawan tattaunawa tana kan wani tasirin komawar sigina ko yaɗuwar rediyo da ya shafi kankara da kusancin sararin gani, ko matsalar na’ura ko bincike. Babu wanda aka tabbatar. Don haka takaitaccen bayani na gaskiya shi ne: fassarar da ta fi jan hankali ta samu babbar illa, amma har yanzu ba a san dalilin ba.

Abin da wannan *bai tabbatar ba*

- **Bai gano** abin da bugun sigina biyun suke ba. “Yana rage yiwuwar sabuwar kimiyyar lissafi sosai” ba yana nufin “an warware” ba.
- **Bai tabbatar** da dalili na yau da kullum ba. Babban zato — komawar sigina daga ƙarƙashin saman Antarctica — har yanzu zato ne, ba sakamako ba.
- **Bai gano** wani abu “daga ƙarƙashin kankara” a ma’anar zahiri ba. Anternonin ANITA suna rataye a balon *sama* da Antarctica; “daga ƙasa” yana bayyana alkiblar zuwan bugun rediyo da aka sake lissafawa — ba sauti, murya, ko wani abu da ke fitowa daga cikin kankara ba.
- **Bai goyi bayan** da’awar sabon barbashi da aka tabbatar ba. Shahararriyar sigar wannan labari tana nuna akasin abin da shaidar ta nuna.

Yaya ƙarfin shaidar yake?

Matsakaici ne, kuma an faɗa haka.

- Sha’awar abin da ya wuce Standard Model ta dogara ne kusan gaba ɗaya kan abubuwa **biyu**, daga jiragen ANITA biyu.
- Wannan makala **sakamakon rashin ganowa** ne: yana da ƙarfi wajen kawar da wasu yi-wuwar, amma ba zai iya cewa mene ne abubuwan ba.
- Kawarwar tana da adadi kuma tana da ƙarfi (an yi tsammanin abubuwa da dama, an ga guda ɗaya mai kama da bayan fage) — amma tana nufin fassarar “kwararar ruwan barbashi masu hawa sama,” ba kowace irin dalili da za a iya tunani ba.
- Babban bayani na yau da kullum (komawar sigina kusa da saman kankara) mai yiwuwa ne

amma ba a tabbatar ba; wasu madadin (wasu nau'ikan transition radiation) wasu bincike sun rage musu goyon baya.
- Babu wata gwaji da ta sake samar da matsalar ta asali da kanta.

Wannan ƙaƙƙarfan takura ce da aka ɗora kan ƙaramar matsala mai taurin kai — ba gano sabon abu ba.

Me ya sa yake da muhimmanci

Bayanan da aka gabatar sun kai har ga sabbin barbashi masu ban mamaki. Maimakon bin wanda ya fi jan hankali, fannin ya yi aikin da ba shi da kwalliya: ya gwada ra'ayin da wata babbar na'urar ganowa mai zaman kanta — bayanan kuma suka ce a'a. Ana gina wata na'ura magaji mafi girma da ƙarin ji, PUEO, domin ta sake dubawa.

Wataƙila a ƙarshe matsalar ta zama wani abu na yau da kullum. Hakan ba zai sa ta zama gazawa ba. Rage yiwuwar bayanin ma'aunin da ba a fahimta ba har sai ya ɓace ko ya tilasta ainihin ganowa *shi ne* aikin — kuma ya dace a kalla musamman domin amsar gaskiya, a yanzu, har yanzu ita ce "ba mu sani ba."

Takaitaccen bayani

Bugun rediyo biyu daga jiragen balon ANITA na Antarctica a 2006 da 2014 sun bayyana kamar sun zo daga gangaren da ke ƙasa sosai da sararin gani, waɗanda Standard Model ke da wahalar bayyanawa. Wani bincike na musamman na 2025 da Pierre Auger Observatory ya yi ya sami abin da ake zargi guda ɗaya kawai, wanda ya yi daidai da bayan fage, inda ya kamata a ga abubuwa da dama idan bugun sun fito ne daga kwararar ruwan barbashi masu hawa sama. Wannan yana rage yiwuwar fassarar "sabon barbashi" sosai kuma yana nuna wata komawar sigina, yaɗuwa, ko tasirin na'urar da ya shafi ANITA — amma har yanzu ba a san dalilin ba. Ba sabon barbashi da aka tabbatar ba ne, kuma ba sigina ne mai ban mamaki daga cikin kankara ba.

Binciken ba tare da ƙarin gishiri ba

Abin da makalar ta nuna: Binciken makaho na Pierre Auger (2004–2018) na ruwan barbashi na iska masu hawa sama ya sami abin da ake zargi guda ɗaya, wanda ya yi daidai da bayan fagen cosmic ray na abubuwa 0.27 da ake tsammani. Idan matsalolin ANITA sun fito ne daga kwararar irin waɗannan ruwa, Auger ya kamata ya ga kusan 34–69 (ko aƙalla ~8 a ƙarƙashin zato mai taka-tsantsan). Wannan yana rage yiwuwar fassarar ruwan barbashi masu hawa sama sosai, har da yanayin "sabon barbashi" da ya wuce Standard Model.

Abin da mai yiwuwa ne amma ba a tabbatar ba: Tasirin komawar sigina ko yaɗuwar rediyo kusa da kankara da sararin gani, ko matsalar na'ura/bincike da ta shafi ANITA.

Abin da ba ta nuna ba: Cewa sabon barbashi ne ya haifar da abubuwan; cewa sigina ne daga ƙarƙashin kankara; cewa wani abu na ban mamaki, na ƙera, ko mai sauti yana ciki; ko cewa yanzu an san dalilin.

Manyan iyakoki: Sha'awar abin da ya wuce Standard Model ta dogara da kusan abubuwa biyu; wannan sakamakon rashin ganowa ne da ke takurawa amma ba ya gano dalili; kawar-war ta shafi fassarar "kwararar ruwa" musamman; babu sake samar da matsalar ta asali daga wata gwaji mai zaman kanta.

Yaya ƙarfin amincewar mai karatu na yau da kullum ya kamata ya kasance? Babbar amincewa cewa wannan *ba* sabon barbashi da aka tabbatar ba ne kuma *ba* sigina daga cikin kankara ba ne, kuma yanzu an rage yiwuwar fassarar kwararar barbashi masu ban mamaki sosai. Karamar amincewa game da ainihin dalilin, wanda har yanzu buɗe yake. Matsayin da ya dace: sha'awar matsalar da ba a warware ba wadda ta fi yiwuwa ta zama ta yau da kullum.

Majiyoyi

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