The Clean Paper

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

DESI cosmic ruler isaa isa sirrii, fi dark energy irratti 'tarii' of-eeggannoo qabu

DESI universe expansion history objects million ja'a irraa baryon-acoustic ruler hanga ammaatti caalaatti precise ta'een safare. Qofti isaa standard model dark energy constant ta'e waliin walsima. DESI CMB fi supernova sample waliin combine yeroo godhamu qofa evolving dark energy preference mul'ata — supernovae kam dabalamu irratti hundaa'uun 2.6σ hanga 3.9σ, discovery threshold physicists barbaadan gadi fi paired data irratti sensitive. Gaaffii dhugaa precise ta'e, deebii miti.

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Safartuu sound irraa ijaarame

Addunyaa jalqabaa keessatti, urjiileen uumamuu dura, pilaazmaa ho'aan barbaachisaa idilee fi ifa walitti makame "ring" godha ture. Dhiibbaa waves saffisa ifa walakkaa caalaa saffisaan keessa deeman, hanga addunyaa qabbanaa'ee atoms uumamanitti; sana booda ringing dhaabbatee fageenya filatamaa dadhabaa tokko distribution barbaachisaa keessatti freeze godhe. Fageenya sun, **sound horizonii**, har'a naannoo 150 megaparsecs (gara 490 miliyoona light-years) dha; galaaksiiwwan fageenya sanaan wal irraa fagaatan irratti excess xixiqqaa, kallattii hunda fi epochs hunda keessatti mul'ata. Cosmologists kana **baryon acoustic oscillation (BAO)** jedhu; istaandaardii ruler ta'ee fayyadama: dhaabbataa taasifame safartuu sun fageenya adda adda irratti samii keessatti hammam akka guddaa fakkaatu safari, addunyaa seenaa isaa keessatti hammam saffisaan expand akka ta'e kaartaa goota.

Dark Anniisaa Spectroscopic Instrument (DESI) ruler kana nama hundaa caalaa sirriitti safaruuf ijaarame. Jalqabaa daataa gadhiisuu isaa galaaksiiwwan, quasars fi Lyman-alpha forest gas clouds fagoo keessatti BAO safartuu kaartaa godha — objects miliyoona ja'a ol, redshift bins torba redshift 0.1 irraa 4.2tti. Namaa expectation bu'aa keessatti akka hin seene, teamichi xiinxala **odeeffannoo garee dhoksee** godhe; cosmological deebii ofumaan irraa dhoksee hanga malleen lock ta'anitti. BAO safartuu hanga ammaatti caalaatti sirrii ta'e dha.

DESI Nicholas U. Mayall 4-metre Telescope Kitt Peak, Arizona irratti mounted dha. Instrument kun optical fibres kumaatamaan ifa spectrographs keessa ergee, samii irratti positions gara speektra fi redshifts galaaksiiwwan fi quasars miliyoonaan lakkaa'amanitti jijjiira.

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DESI maal dha

Dark Anniisaa Spectroscopic Instrument jechuun spectrograph Nicholas U. Mayall 4-metre telescope Kitt Peak, Arizona irratti jiru. Dark anniisaa kallattiin hin argu — dark anniisaa ifa hin baasu. Kana irra, yeroo tokko keessatti galaaksiiwwan fi quasars naannoo 5,000 speektra isaanii galmeessa, addunyaa expand ta'uun ifa isaanii hammam stretch godhe irraa redshift tokko tokko dubbisa, fi kaartaa sadii-dimenshinii objects miliyoonaan lakkaa'aman ijaara. Dark anniisaa kaartaa sana keessaa cosmic expansion yeroo waliin akkamitti jijjiirame irraa infer godhama. Karaa guutuu — robotic fibres irraa hanga acoustic ruler — Akkam DESI works ilaali.

mata-duree irraa faca'e: dark anniisaa dhaabbataa ta'uu dhiisuu danda'a — wanti addunyaa expansion saffisiisaa jiru **yeroo waliin dadhabaa** ta'uu danda'a, istaandaardii cosmological moodeela irratti crack bana. Himannaa kun invented miti, garuu over-read gochuun salphaa dha. Gosa amanamaan caalaatti addaa fi interesting dha: **DESI ruler mataan isaa, qofti isaa, plain-vanilla moodeela waliin wal-sima.** Hint wanta haaraa DESI daataa biroo waliin combine yeroo godhamu qofa mul'ata — fi hint hammam akka cimaa fakkaatu daataa alaa kam waliin walitti makame irratti hirkata.

DESI baryon-acoustic ruler qofti isaa dhaabbataa dark anniisaa (cosmological dhaabbataa) waliin wal-simu dha. Preference **evolving dark anniisaa** DESI cosmic microwave duubbee fi supernova saamudaa waliin combine yeroo godhamu qofa mul'ata; strength isaa supernova saamudaa filatame waliin jijjiirama.

Istaandaardii ruler, fi dark anniisaa karaa lama jijjiiramuu danda'u

BAO safartuu **istaandaardii ruler** dha: fiiziksii addunyaa jalqabaa irraa true length isaa waan beeknuuf, true length fi apparent hammamtaa fageenya tokko irratti wal-bira qabachuun addunyaa yeroo sanaatti hammam expand akka ta'e hima. Fageenyota hedduu irratti safaruun expansion seenaa guutuu hordofa — dark anniisaa isa bulchu.

Istaandaardii moodeela ΛCDM keessatti dark anniisaa **cosmological dhaabbataa** dha: anniisaa density vacuum dhaabbataa, yeroo waliin hin jijjiiramne. Physicists amala isaa paaraameetira "equation of haala" w jedhamuun ibsu; true cosmological dhaabbataa'f gatii isaa exactly -1 dha, bakka hunda, yeroo hunda.

Kana qoruuf karaa lama loosen gochuu dandeessa. Karaan salphaan w gatii biraa dhaabbataa ta'u eeyyamu — "wCDM." Karaan bal'aan w addunyaa expand ta'aa yeroo jijjiiramuu eeyyama, lakkoofsota lama w_0 (har'a gatii isaa) fi w_a (drift saffisa) fayyadamuun. "w_0w_aCDM" moodeela kun qabxii $w_0 = -1,\ w_a = 0$ irratti ΛCDM ta'a. Preference w_0 -1 caalaa guddaa fi w_a negaatiivii ta'uun as "evolving dark anniisaa": dark anniisaa duraan caalaatti repulsive ture, amma easing off ta'aa jira.

Barreessitoonni maal godhan

- DESI year-one daataa — galaaksiiwwan, quasars fi Lyman-alpha forest — objects miliyoona ja'a ol, redshift bins torba $0.1 < z < 4.2$ keessatti BAO safartuu safaran.
- Xiinxala **odeeffannoo garee dhoksee** godhan; cosmological bu'aa methodology lock ta'uu dura dhoksan, confirmation bias hir'isuuf.
- Flat ΛCDM moodeela DESI BAO qofa irratti fit godhan, achiis big-bang-nucleosynthesis duraa fi CMB Planck fi ACT waliin combine godhan.
- Moodeela karaa lama expand godhan: dhaabbataa dark-energy w (wCDM), fi time-varying $w_0 w_a$ ($w_0 w_a$CDM).
- Time-varying moodeela DESI+CMB waliin gosa Ia supernova compilations sadii — Pantheon+, Union3 fi DES-SN5YR — tokko tokkoon combine godhanii qoran, tokko qofa filachuu dhiisanii.
- Summed neutrino maassaa irratti daangaalee kaa'an; dark-energy duubbee ΛCDM irraa jijjiiramuu eeyyamame bounds akkamitti socho'an illee qoran.

Maal argatan

- **DESI BAO qofti istaandaardii moodeela waliin wal-simu dha.** barbaachisaa density $\Omega_m = 0.295 \pm 0.015$; dark anniisaa dhaabbataa w akka jijjiiramaa ta'etti eeyyamame $w = -0.99^{+0.15}_{-0.13}$ — cosmological-constant gatii -1 irratti jechuun danda'ama.
- CMB fi lensing waliin, DESI $\Omega_m = 0.307 \pm 0.005$ fi Hubble dhaabbataa $H_0 = 67.97 \pm 0.38$ km s^{-1} Mpc^{-1} kenna (68.52 ± 0.62 nucleosynthesis fi CMB acoustic safartuu waliin).
- **Time-varying moodeela keessatti combinations evolving dark anniisaa filatu** — $w_0 > -1$ fi $w_a < 0$. Preference DESI+CMB'f 2.6σ dha; supernova saamudaa dabaluun Pantheon+, Union3 fi DES-SN5YR irratti respectively 2.5σ, 3.5σ, 3.9σ ta'a. Sigma standard-model expectation irraa fageenya safara; discovery convention yeroo baay'ee 5σ dha, fi barbaachisummaa istaatistikii qofti hiika sirrii ta'uu hin mirkaneessu — qajeelfama.
- Summed neutrino maassaa free ta'ee, DESI+CMB irratti 95% amanamummaa keessatti **0.072 eV gadi**; garuu barruun dark-energy duubbee ΛCDM irraa jijjiiramu eeyyamame bound baay'ee loosen ta'a jedhu.

Kun maal hin mirkaneessu

- Dark anniisaa evolving dha jechuu **hin agarsiisu**. DESI ruler mataan isaa cosmological dhaabbataa waliin wal-simu dha; hint evolution walitti makame fits fi two-parameter richer moodeela keessatti qofa mul'ata.
- "ΛCDM du'e" yookaan "Einstein dogoggore" jechuu miti. Lakkoofsi cimaan 3.9σ, physicists discovery jedhanii waamuuf 5σ convention gadi; DESI qofti istaandaardii moodeela gaariin fit godha.
- Bu'aa **saamudaa-independent miti**. Supernova compilation jijjiiruun barbaachisummaa istaatistikii 2.5σ irraa 3.9σ tti sochoosa — sigma tokko caalaa. Mallattoo alaa kuusaa daataa kam itti

dabalame irratti hammam akkas depend godhu, hordoffii hint dha, bu'aa banked miti.

- DESI-alone lean $w_0 > -1$ **gariin tokko anomalous qabxii** — redshift-0.51 galaaksii bin ΛCDM caalaa xiqqoo ol — irraa dhufa. Garuu barruun homework isaa godha: qabxii sana istaatistikii fluctuation akka ta'etti ilaala, fi DESI low-redshift ($z < 0.6$) safartuuwwan hunda SDSS duraanii waliin replace gochuun dark-energy bu'aa hin jijjiiru agarsiisa. Odd qabxii DESI qofa irratti tugs, walitti makame hint hin baatu. Kanaaf caveat kun bu'aa dadhabsiisu qofa miti; stress qormaata keessa darbe agarsiisa.
- Neutrino-mass daangaa **model-independent verdict miti**. ΛCDM duubbee irratti tight dha; duubbee loosen gochuun bound illee loosen ta'a.

Ragaan hammam cimaa dha

- **Fageenya safartuu ta'een baay'ee cimaa.** BAO cosmology meeshaalee qulqulluu keessaa tokko; DESI safartuu isaa hanga ammaatti sirrii dha; odeeffannoo garee dhoksee xiinxala hoped-for deebii daataa keessaa dubbisuu irraa eeguuf safeguard sirrii dha.
- **Dark-energy himannaa ta'een dhugumaan intriguing, garuu decisive miti.** DESI+CMB 2.6σ, supernova set tight waliin 3.9σ — bu'aa telescope yeroo dabalataa argachuu qabu, moodeela overthrow gochuu miti. Caution ijoo supernova saamudawwan gidduu spread dha; barreessitoonni anomalous BAO qabxii isaanii bu'aa sochii hin goone illee qoratan.
- barruun of irratti of-eeggannoo qaba: barbaachisummaa istaatistikii karaa sadii gabaasa godha, isa guddaa qofa hin quote godhu; neutrino bu'aa model-dependence flag godha. Overreach, yoo jiraate, retelling keessatti, barruu keessatti miti.

Maaliif barbaachisaa dha

Waggaa 25f "dark anniisaa" fi "cosmological dhaabbataa" jechuun jechuun ni danda'ama interchangeable turan, sababni isaas safartuuwwan hundi w -1 waliin wal-simu turan. DESI kuusaa daataa jalqabaa sirrii gahaa ta'e, daataa biroo waliin, -1 sun drift godhaa? jechuun gaaffii gaafachuu fi flat "lakki" caalaa deebii argachuu danda'e. Kun daataa maal gochuu danda'u irratti jijjiirama dhugaa dha; kanaaf attention qabaachuu qaba. Garuu sirrummaa sanuma hint conditional ta'uu mul'isa: combinations muraasa keessatti jira, kanneen biroo keessatti quiet, fi supernova catalogue kam DESI waliin pair godhamu irratti sensitive.

Posture sirrii dismissal miti, revolution jalqabaa announcement illee miti. DESI gadhiisuu itti aanu, DR2, fi walaba supernova saamudawwan ilaali; drift sun jabaataa moo fade godha? Cosmology keessatti **maybe dhugaa** akkas fakkaata, fi maybe ta'ee gabaasa gochuun gatii qaba.

Cuunfaa gabaabaa

DESI addunyaa expansion seenaa BAO ruler hanga ammaatti caalaatti sirrii ta'een, objects miliyoona ja'a irraa, safare. Qofti isaa, ruler sun istaandaardii moodeela dark anniisaa dhaabbataa ta'e waliin wal-sima. CMB fi supernova saamudaa waliin combine gochuun dark anniisaa yeroo waliin jijjiiramu preference mul'ata — 2.6σ hanga 3.9σ, supernovae kam dabalte irratti hundaa'uun. Kun hint dhugaa fi nama hawwatu dha, discovery miti: physicists daangaa barbaadan gadi, fi supernova daataa pairing waliin jijjiirama. Dark anniisaa evolving ta'uu danda'a. DESI gaaffii kana sirrii gochuu jalqabe — ammaaf deebii hin kennine.

Maddoota

DESI Collaboration, arXiv:2404.03002 (published in JCAP)
https://arxiv.org/abs/2404.03002

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