Experimental NuMath/Physics Using Maple

Selden Crary

Palo Alto, California, USA

presented to

Maple Conference 2023

October 27, 2023

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Speaker biography

Credentials: Ph.D., Physics, Univ. of Washington, Seattle, 1978. Dissertation in experimental condensed-matter physics.

Selden was an undergraduate at Brown University and received his Ph.D. in physics from the University of Washington, Seattle, with a dissertation in experimental condensed-matter physics.

He has held faculty positions at Amherst College and The University of Michigan, as well as visiting faculty appointments at The University of Massachusetts, the Technical University of Denmark, and the Swiss Federal Institute of Technology in Lausanne. Selden also has industrial experience at General Motors Research Laboratories and has participated on National Science Foundation and National Research Council advisory committees. He also has a consulting practice focused on advanced applications of design and analysis of experiments.

Selden was a pioneer in MEMS modeling, biobotics, and microflight.

In the last three decades, Selden's principal interest has been design and analysis of experiments. In 1989 he became a vocal advocate of computer-generated optimal designs, and in 2002 he launched the free Web portal, WebDOE.com, to promote these non-classical designs. At its peak in 2009, WebDOE had more than 3500 registered users.

At present, his research is focused on a new class of designs for computer simulations.

Acknowledgments

Optimal design-of-experiments co-authors[1]:

Physical experiments: Wayne Baer, John Cowles, Kensall Wise, Mark Sherwin, Gordon Munns, Michael Elta, E. G. Woelk, Fred Terry, George Haddad, Ling Hoo, Mark Tennenhouse, Mark Snow, Cosimo Spera, Peter Cousseau, David Armstrong, Eva Mok, Olivier Dubochet, Philippe Lerch, Philippe Renaud, Yousceek Jeong, Hee-Jung Lee, Bachar Affour, David Bernstein, Yogesh Gianchandani, and Mary Ann Maher.

Twin-point designs for computer experiments: David Woodcock, Andreas Hieke, Rachel Johnson, Jan Stormann, Michael Saunders, Tatiana Nizhegorodova, Richard Diehl Martinez, Amin Mobasher, and Nikoloz Chkonia.

Special thanks to: Bruce Pourciau (Lawrence U.), Max Morris (Iowa St. U.),

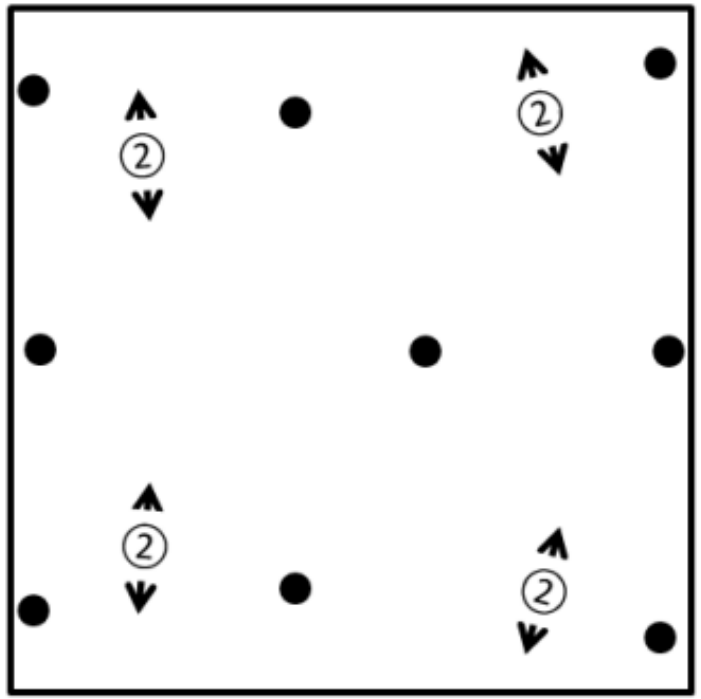
Linda Haines (U. Pietermaritzburg, now Cape Town), Pinaki Mazumder (U. Michigan, Ann Arbor), Fred Hickernell (Illinois Inst. Tech.), Bradley Jones (SAS/JMP), Hermann Schichl (U. Vienna), Avery Bedows, Graham Gyatt, Éttore Vitali (U. California, Fresno), and Marat Markin (U. California, Fresno).

[1]Partial paper list: https://seldencrary.com/pubs/

Experimental NuMath/Physics Using Maple

Two topics: DACE and NuMath/Physics (Slide 1/3)

Design and analysis of computer experiments (DACE), with emphasis on design



Saunders D=2, N=17 optimal design

Authorea: 156277706.69664177

Experimental-mathematics focus

Maple allowed for systematic exploration:

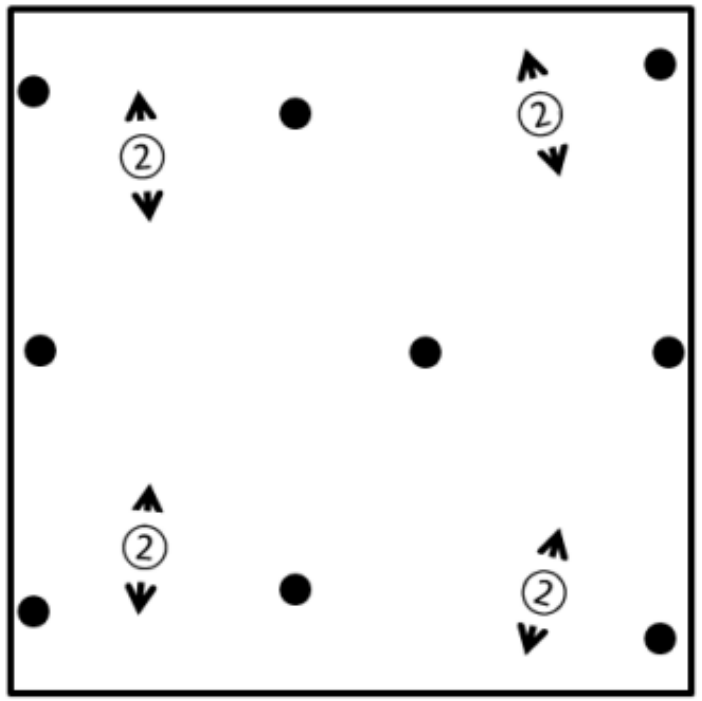
- Downhill search: Digits:=240 not uncommon
- Algebra assistance: Demonstrations & proofs

In this talk: Only 2D "designs" with $N \leq 17$ on square domains are shown, except as noted. These designs have two hyperparameters, θ_1 and θ_2, which, along with the statistical theory, are defined in the references. The concepts and algorithms "work," regardless of D, N, or domain shape.

Experimental NuMath/Physics Using Maple

Two topics: DACE and NuMath/Physics (Slide 2/3)

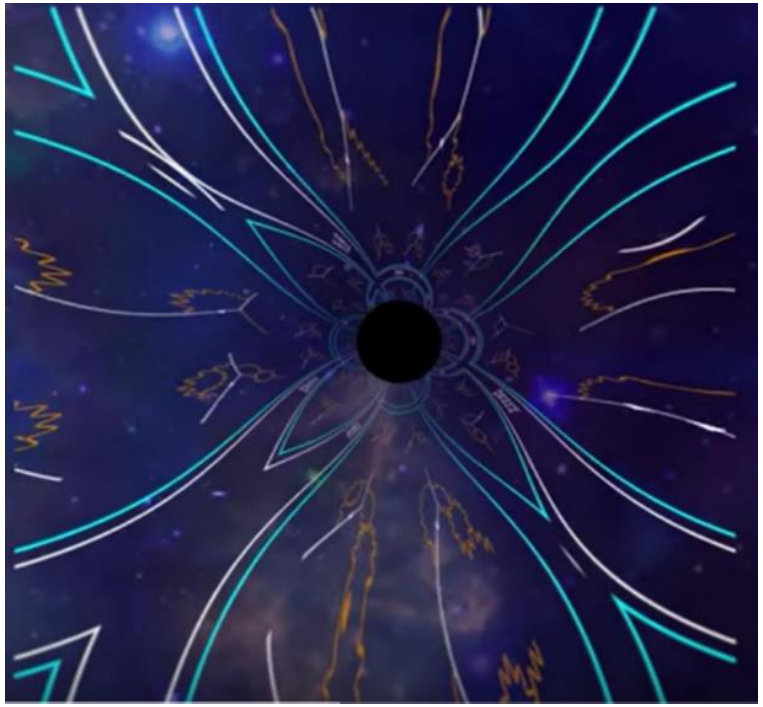
DACE



Saunders N=17 optimal design

Authorea: 156277706.69664177

Today's Physics



Due to the $1/r^2$ singularity, a disk is excluded.

Credit: PBS SpaceTime "Why String Theory is Right"

The Infinity Puzzle*

String theory

Loop quantum gravity

QFT, via renormalization

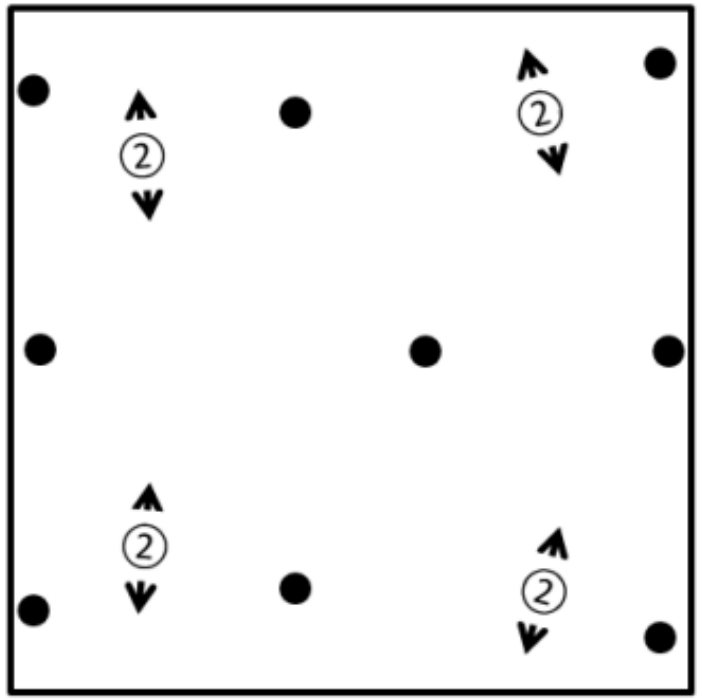
Problems throughout:
- Philosophical
- Conceptual
- Experimental

L. Smolin, The Trouble with Physics, 2006
*F. Close, 2011
L. Smolin, Einstein's Unfinished Revolution, 2019

Experimental NuMath/Physics Using Maple

Two topics: DACE and NuMath/Physics (Slide 3/3)

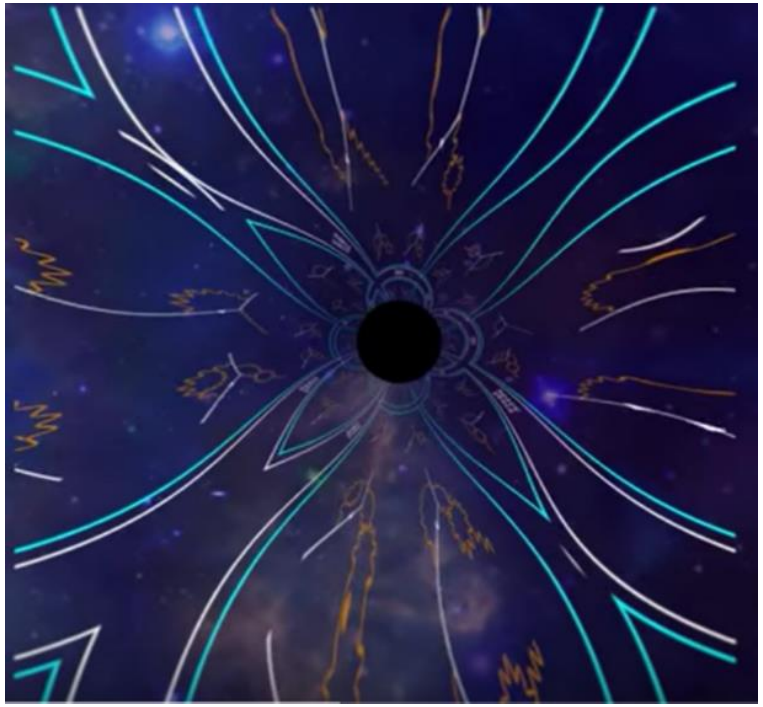
DACE



Saunders N=17 optimal design

Authorea: 156277706.69664177

Today's Physics



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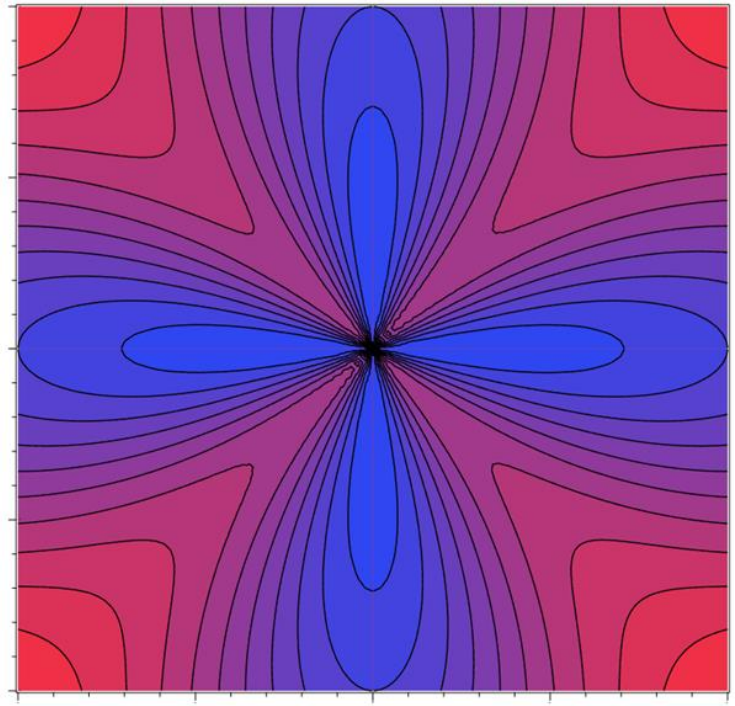
Credit: PBS SpaceTime "Why String Theory is Right"

NuMath/Physics

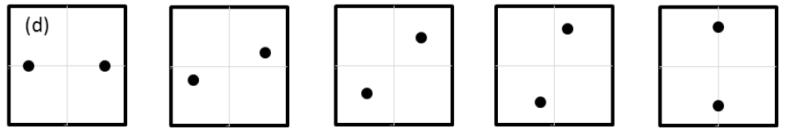


Example DACE objective:
The singularity at the center is integrable.

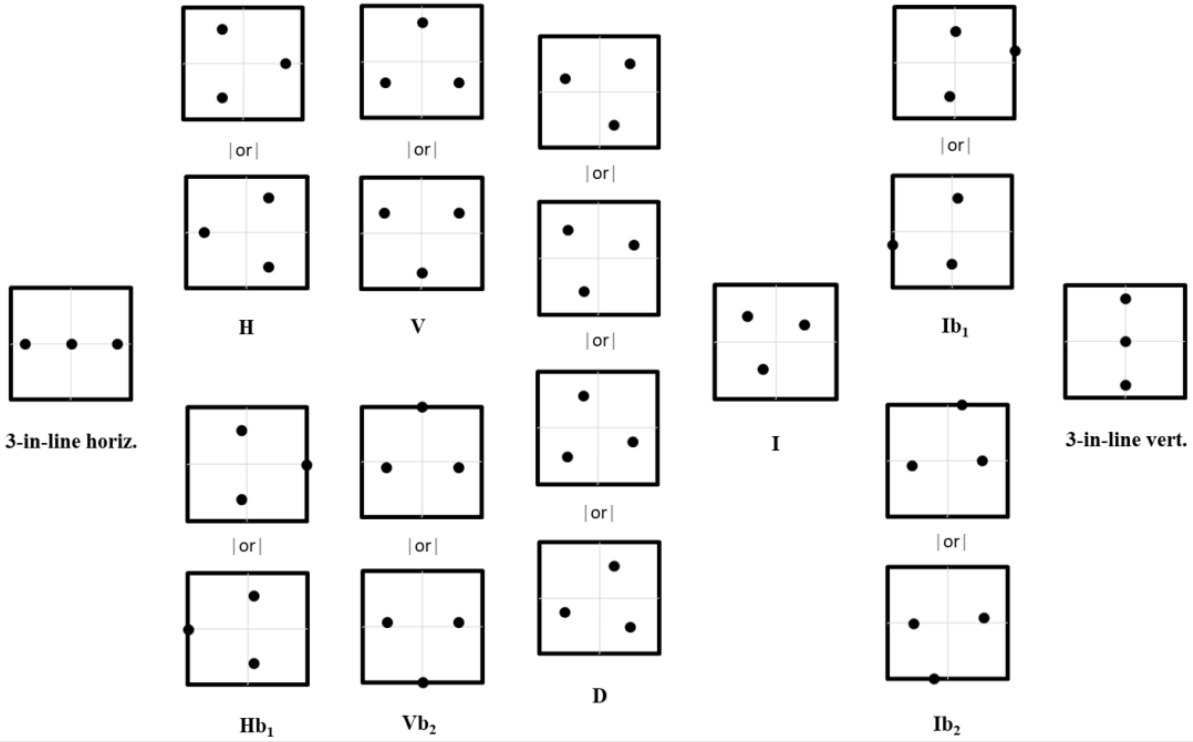
Small-N designs (Slide 1/2)

N=1: Singleton at the origin

N=2



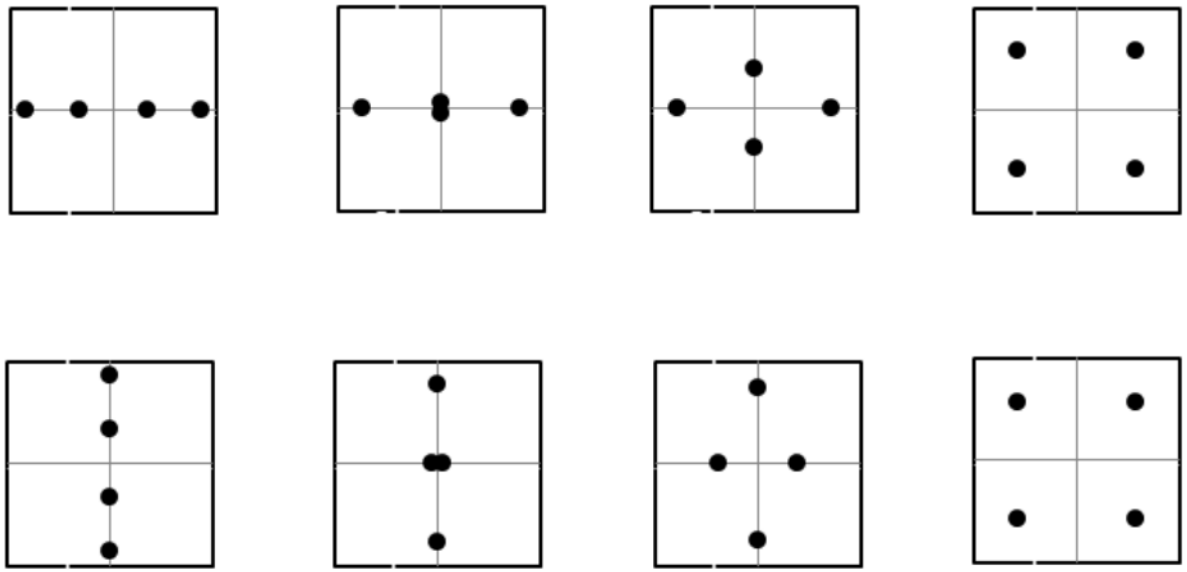
N=3



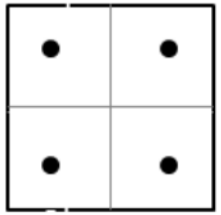
For N=1, 2, or 3:
"Repulsion" dominates.

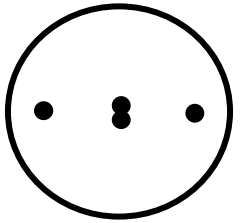
SC, R.D. Martinez, et al.
Authorea:156277706.69664177

Small-N designs (Slide 2/2)



Stormann, Arxiv: 1510.01685





Chakonia design is invariant under rotation.

Arxiv: 1709.09599

Unexpected twins aggregate and disaggregate, under collective "repulsions."

Analogous to black holes?

Racing ahead, with only scant evidence …

Experimental NuMath/Physics Using Maple

The NuMath/Physics quantum-gravity framework (Slide 1/2)

General Relativity & Quantum Mechanics	NuMath/Physics
$\mathbb{C}$	$\mathbb{N}_{maxN}$ and $\mathbb{Q}$ (ultrafinitism)
61 particle types	1 particle type ("preon")
61 fields	1 objective function
Spacetime and curved spacetime	3D Euclidean space & 1D time
Singularities (Big Bang, black holes, size of Universe)	No inverse-sq. law, Universe size is constant
Born's rule	Semideterministic
Extra dimensions, virtual particles, renormalization required at each energy scale, wave functions, wave-function collapse, Hilbert spaces, unitarity, wave-particle duality, the measurement problem, outside observers, Hawking radiation, mysterious dark sector, …	None
Uncertainty principle and Schrödinger's equation	Emergent, as in de la Pena & Cetto's EmQM
Superposition of states	"The cat is either dead or alive."

Experimental NuMath/Physics Using Maple

The NuMath/Physics quantum-gravity framework (Slide 2/2)

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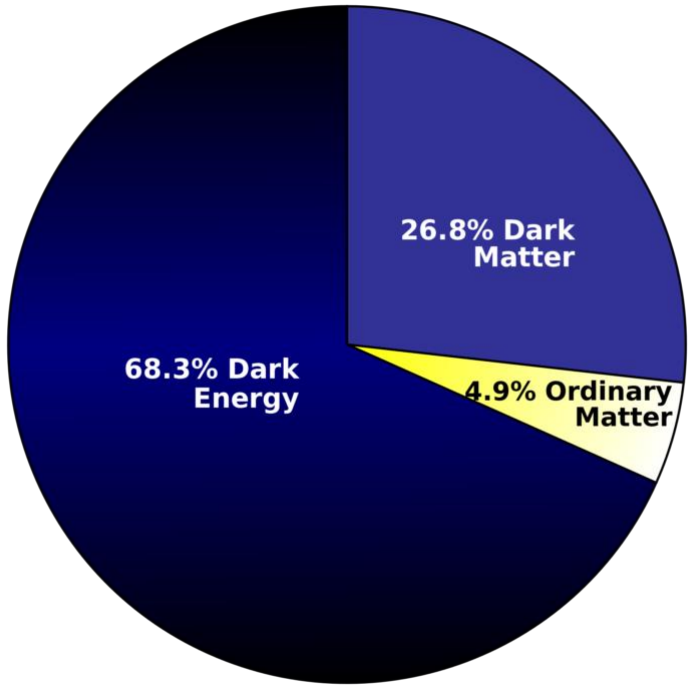
***Thomas Schramm, Rational Trigonometry using Maple, Maple Conf. 2020, and refs. therein.**

Possible connections between NuMath/Physics and the Universe (Slide 1/15)

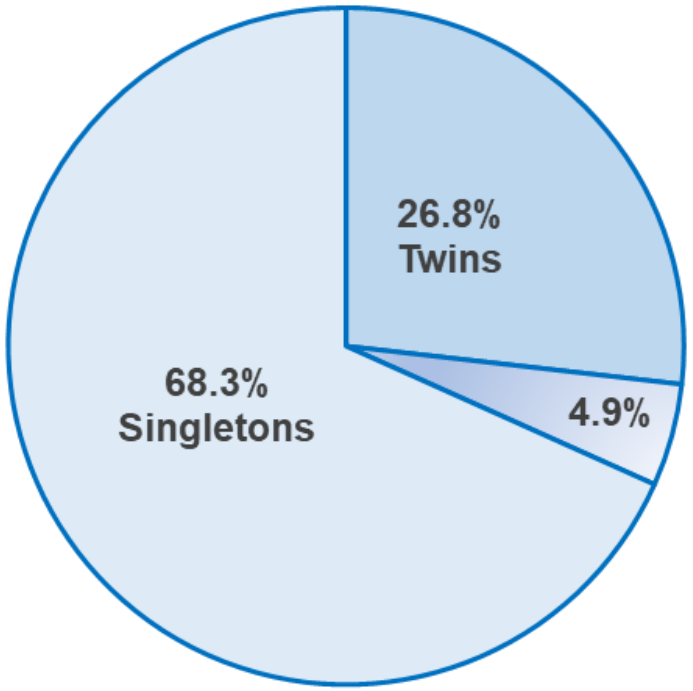
1. “Repulsion” can lead to effective attraction.

Possible connections between NuMath/Physics and the Universe (Slide 2/15)

2. Singleton and twin preons constitute dark energy and dark matter, respectively.



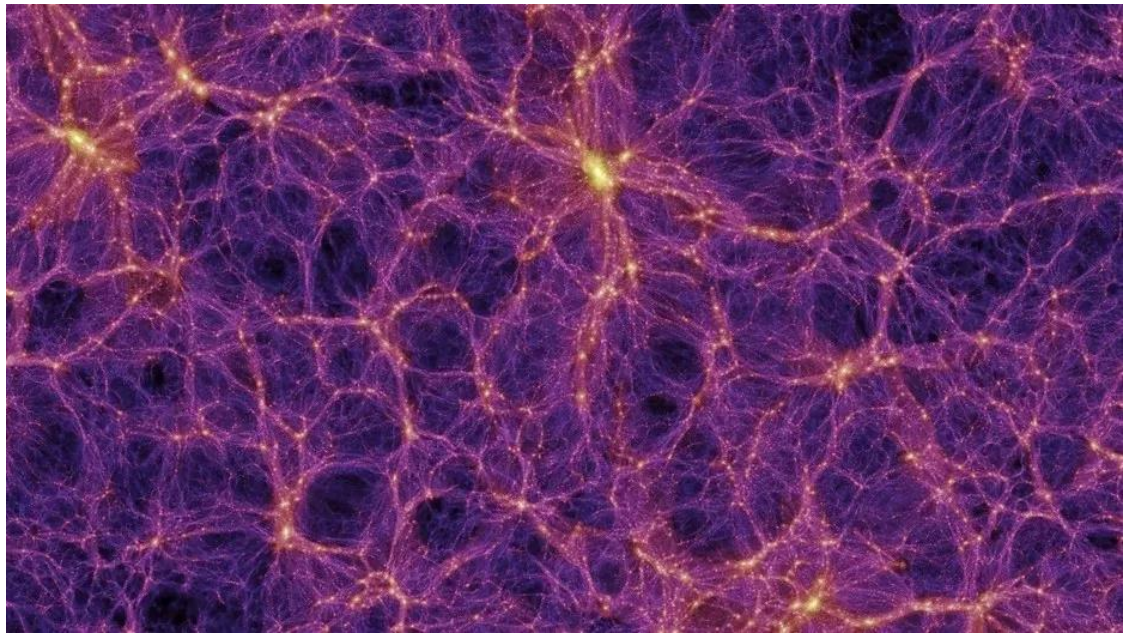
Cosmic energy budget. Credit: Wikipedia



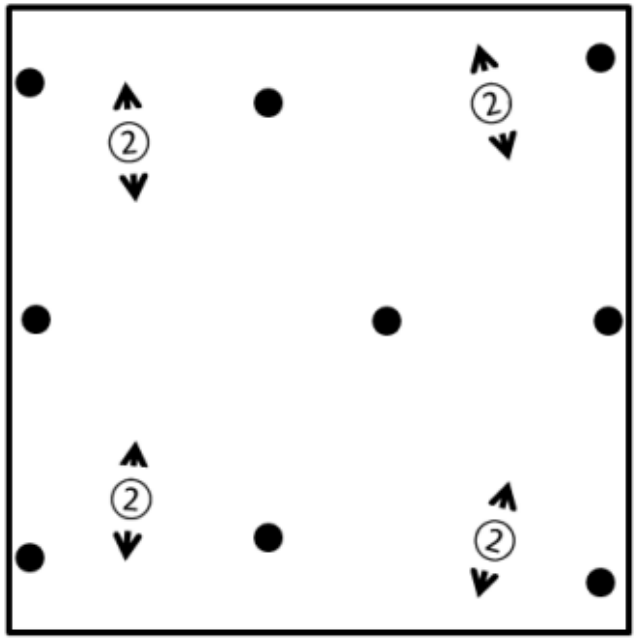
NuNath/Physics energy budget

Possible connections between NuMath/Physics and the Universe (Slide 3/15)

3. The Cosmic Web arises from a NuMath/Physics-based competition between uniformity and aggregation.



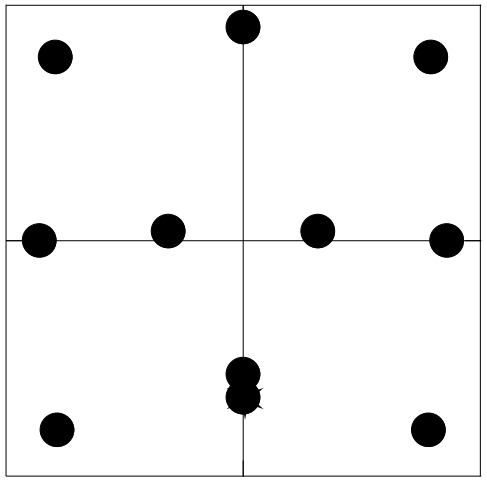
URL: https://www.space.com/james-webb-space-telescope-detects-earliest-cosmic-web-strand
Image credit: ESA/ Springel et al., Virgo Consortium



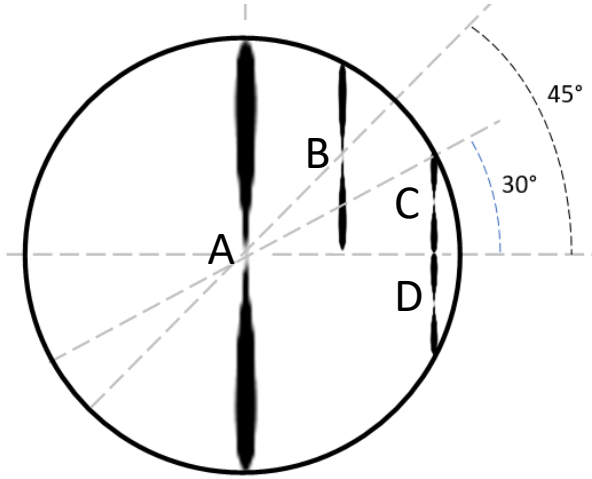
Saunders N=17 optimal design
Authorea: 156277706.69664177

Possible connections between NuMath/Physics and the Universe (Slide 4/15)

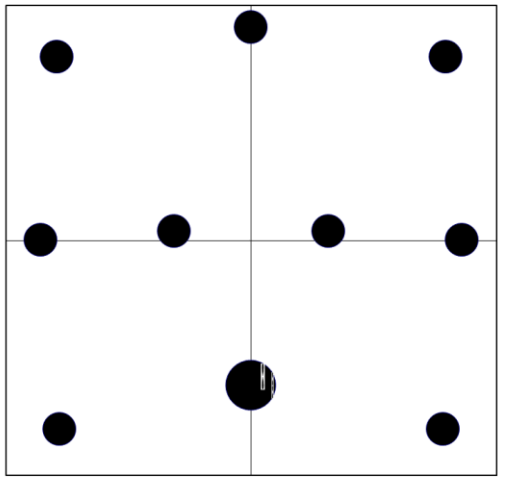
4. “Spherical” black holes



Woodcock N=11 design is optimal in 22D configuration space. The twin separation is exaggerated.



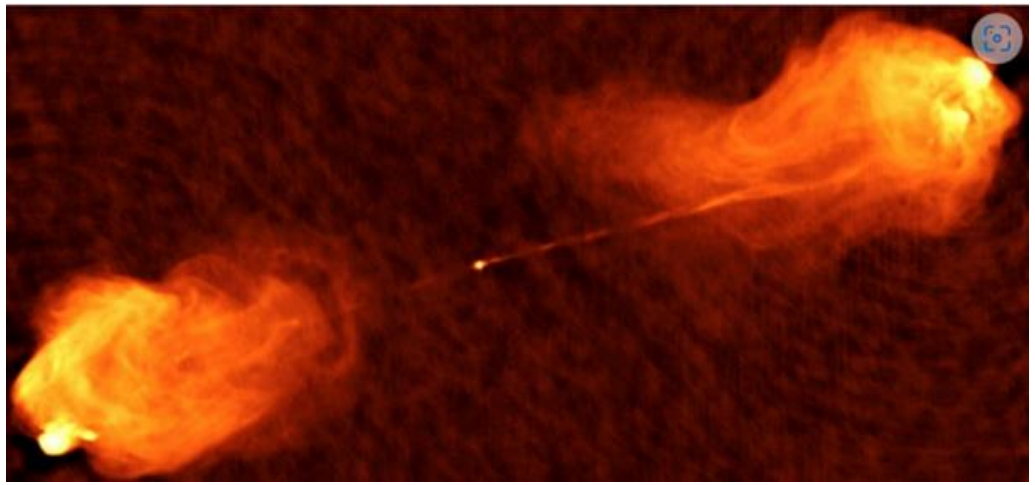
Fixing all singletons; while fixing the twins’ center at A, B, C, or D; yields filled lem-niscate ranges of the twins’ orbits.



With fixed singletons, the range of the twins’ orbits is a circular disk. This is akin to string-theory’s fuzzballs.

Possible connections between NuMath/Physics and the Universe (Slide 5/15)

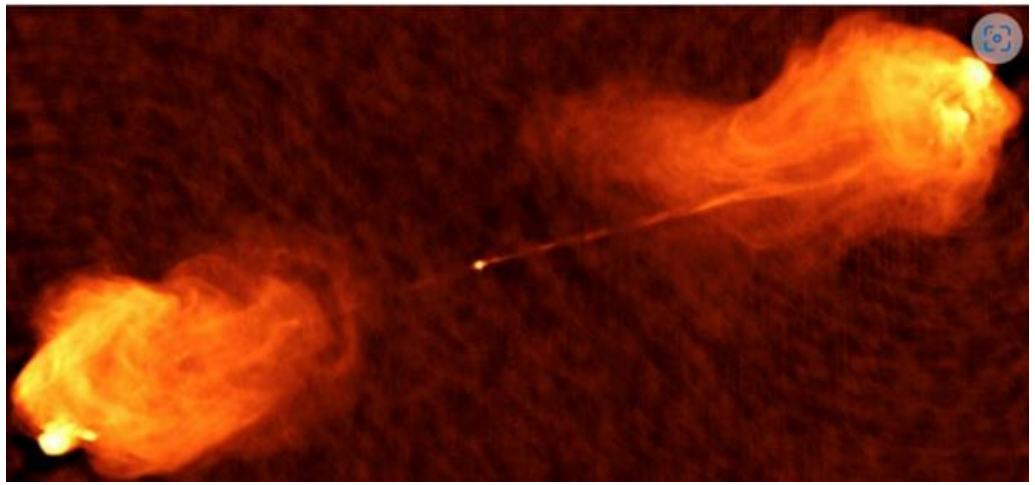
5. Symmetric, bi-conical jets from active galactic nuclei (Slide 1/3)

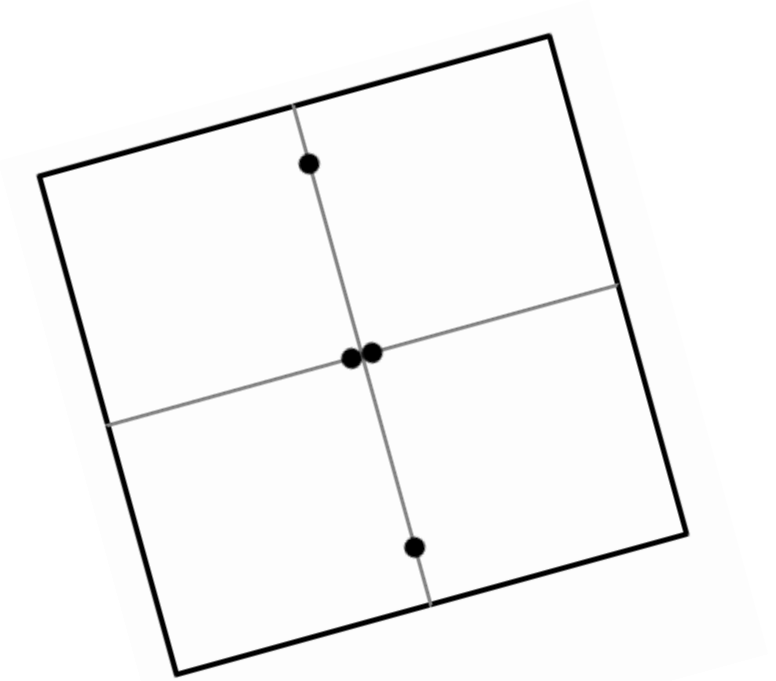


Cygnus A* in radio frequencies.
Credit: National Radio Astronomy Observatory, Arizona U.

Possible connections between NuMath/Physics and the Universe (Slide 6/15)

5. Jets from active galactic nuclei (Slide 2/3)



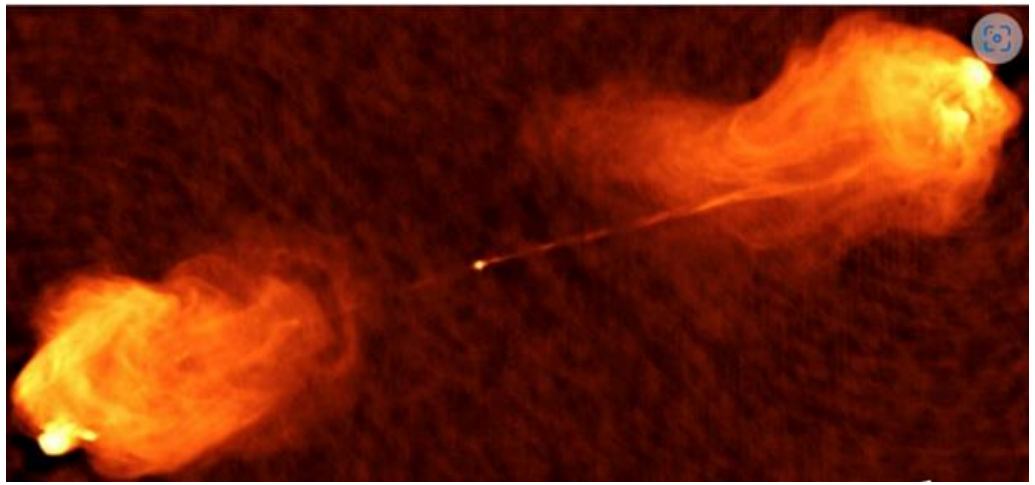


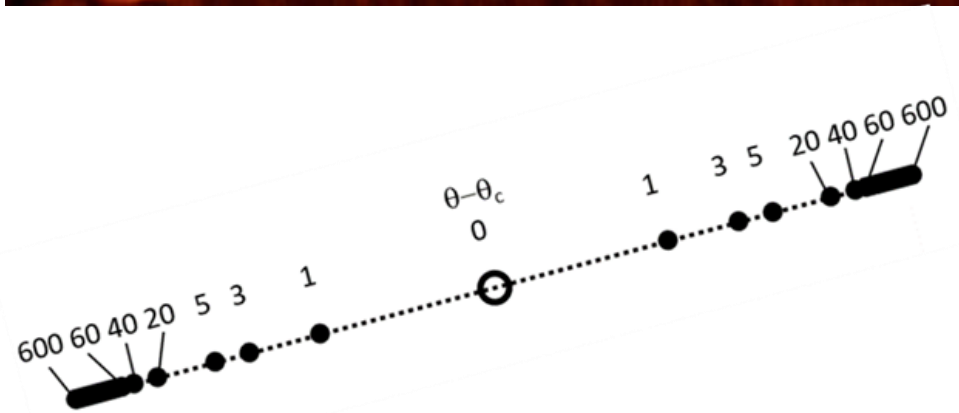
Stormann, N=4, twin-point optimal design

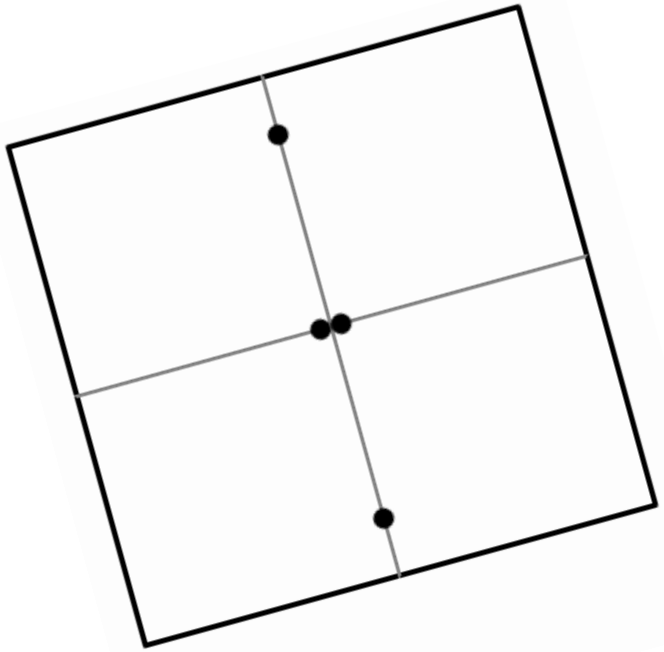
Arxiv: 1510.01685

Possible connections between NuMath/Physics and the Universe (Slide 7/15)

5. Jets from active galactic nuclei (Slide 2/3)

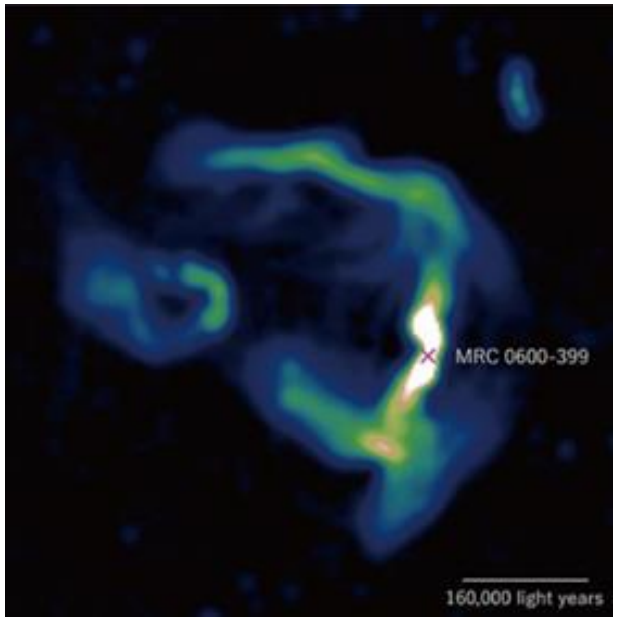






Possible connections between NuMath/Physics and the Universe (Slide 8/15)

6. Double-scythe jets from active galactic nuclei

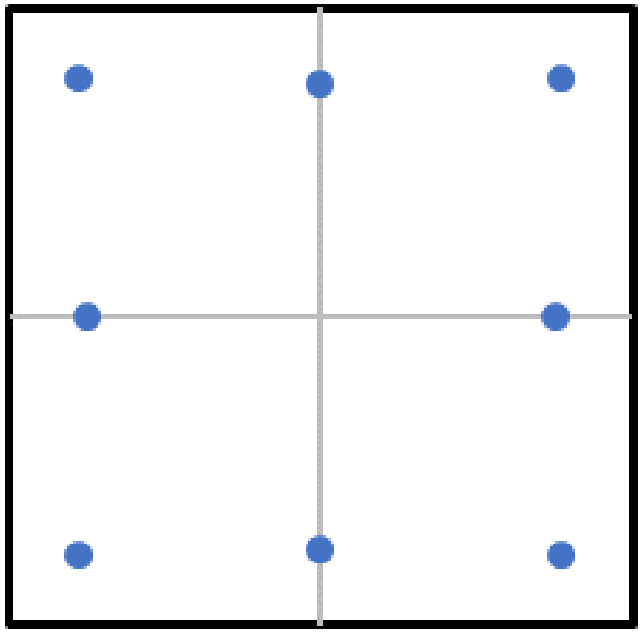


MRC 0600−399
Credit: Chibueze et al., ArXiv: 20210621

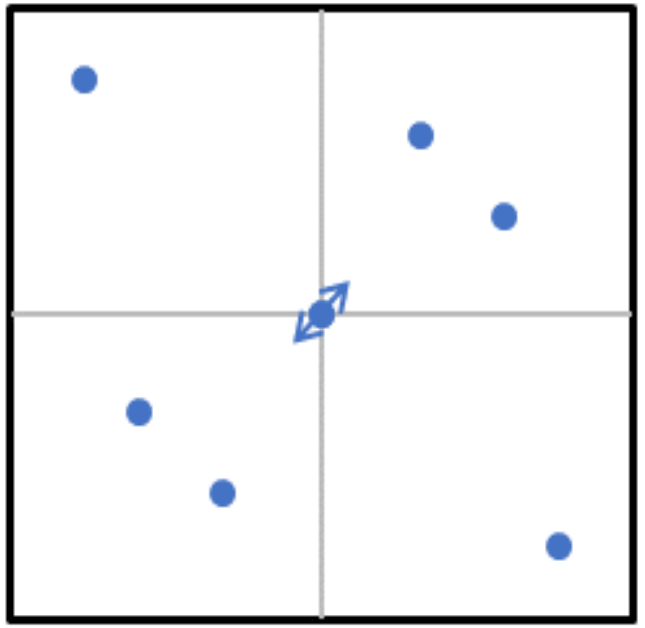
Orbit of two points of the Stormann N=4 designs: Initial ejection of the twin-points is followed by a continuous phase transition causing a ccw (or cw) rotation of the two points.

Possible connections between NuMath/Physics and the Universe (Slide 9/15)

7.1 Inverse-square-law (ISL) behavior from the IMSPE: Ex. 1: $N = 8, \theta_1 = \theta_2 = 0.03$



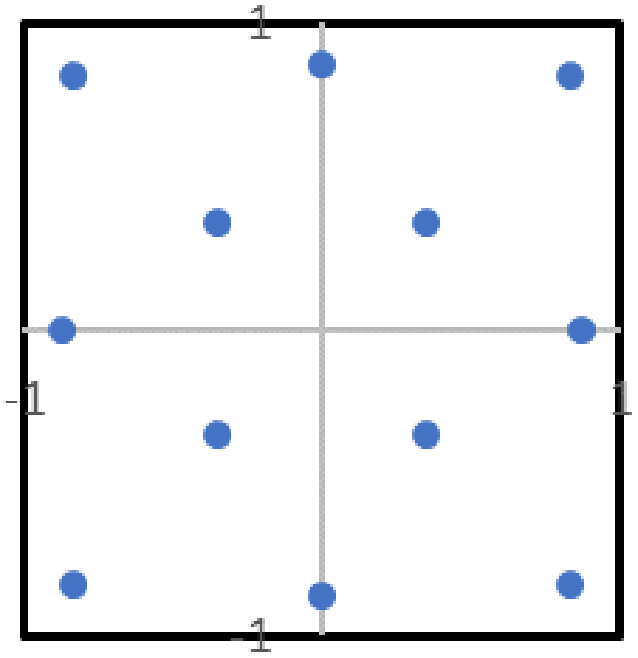
Global minimum



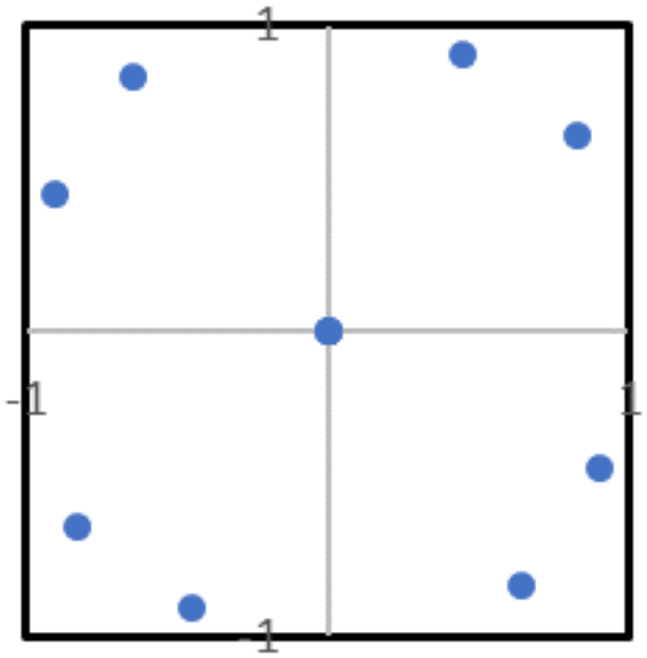
A local minimum, with a central twin-point and an outer "galaxy."

Possible connections between NuMath/Physics and the Universe (Slide 10/15)

7.2 ISL behavior from the IMSPE: Ex. 2: $N = 12, \theta_1 = \theta_2 = 0.128$



The global minimum

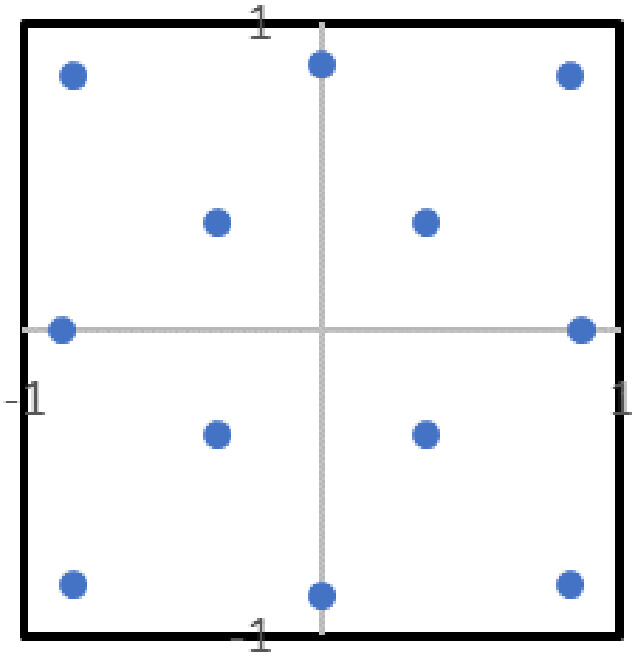


A local minimum, with a central quadruplet (not resolved, in this view) and an outer, irregular octagonal "galaxy."

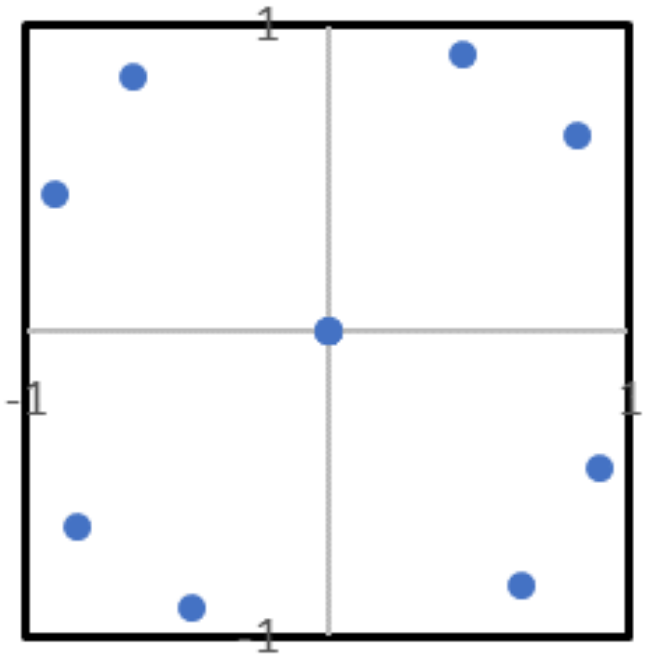
$5x10^{21}$ expanded view of the quadruplet, with a twin (not resolved, in this view)

Possible connections between NuMath/Physics and the Universe (Slide 11/15)

7.3 ISL behavior from the IMSPE: Ex. 2: $N = 12, \theta_1 = \theta_2 = 0.128$



The global minimum



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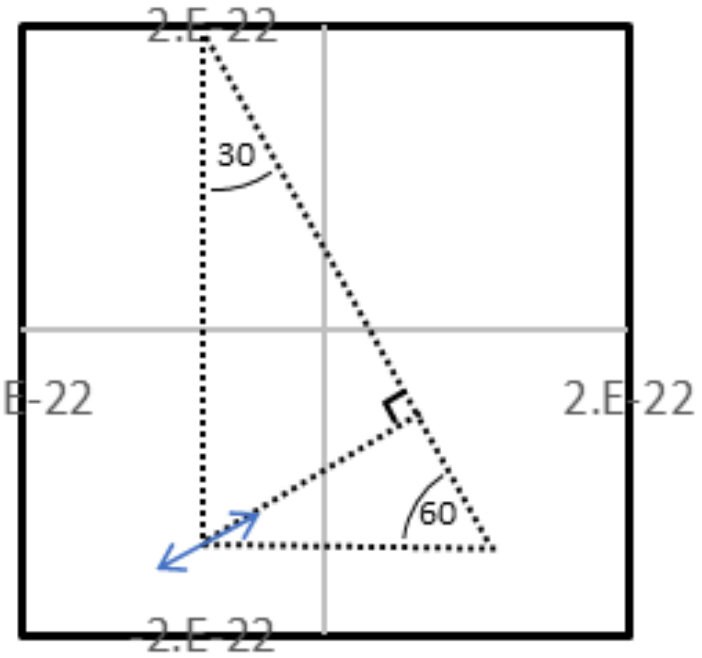
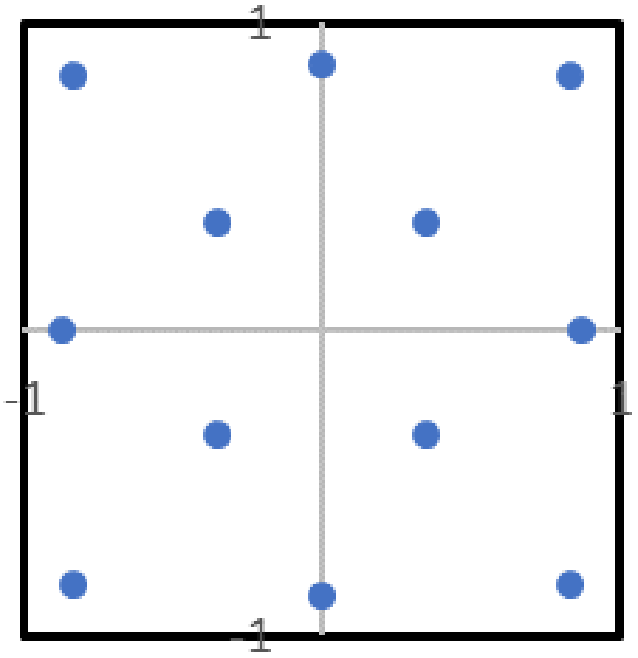


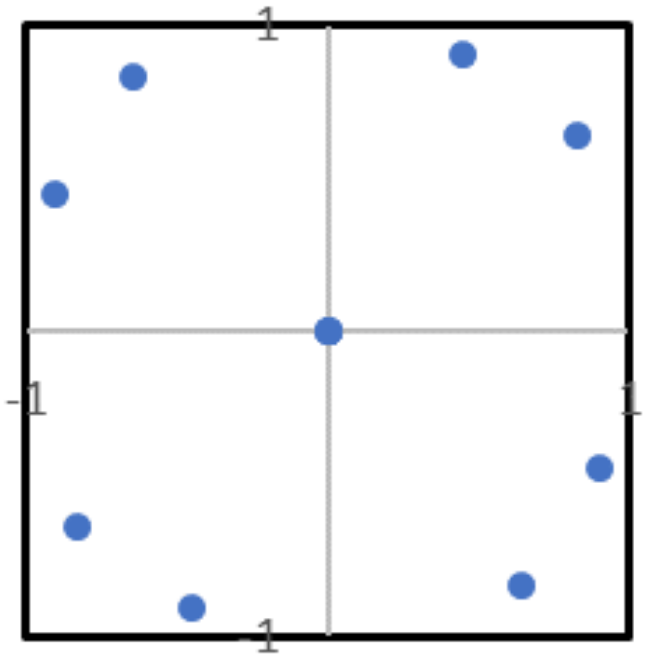
Three of the quadruplet's vertices form a nearly perfect 30-60-90 right triangle, with a twin at the right angle.

Possible connections between NuMath/Physics and the Universe (Slide 12/15)

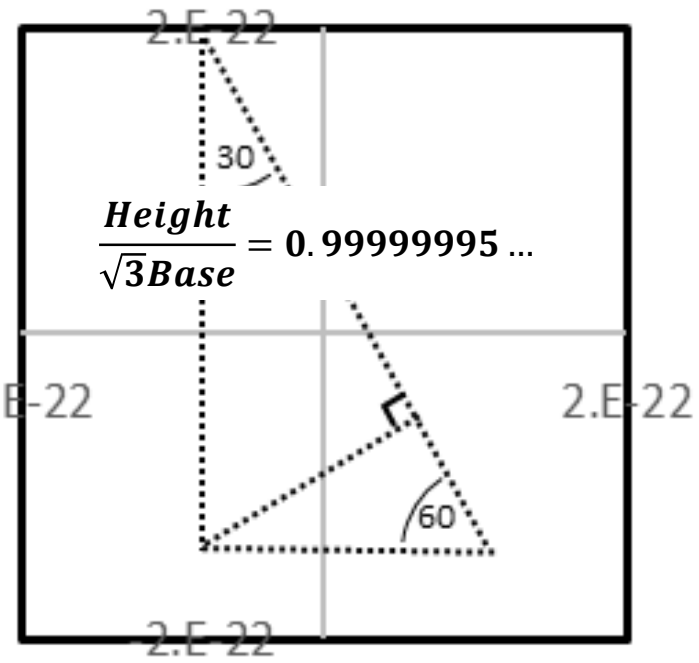
7.4 ISL behavior from the IMSPE: Ex. 2: $N = 12, \theta_1 = \theta_2 = 0.128$



The global minimum



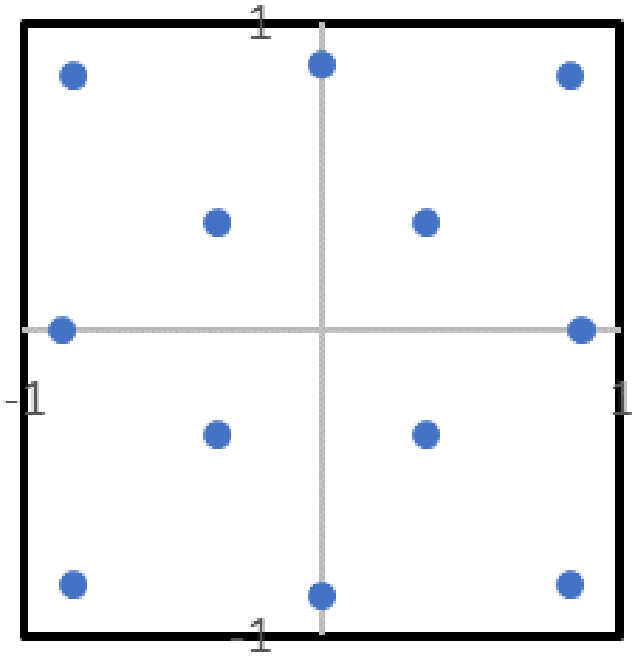
A local minimum, with a central quadruplet (not resolved, in this view) and an outer, irregular octagonal "galaxy."



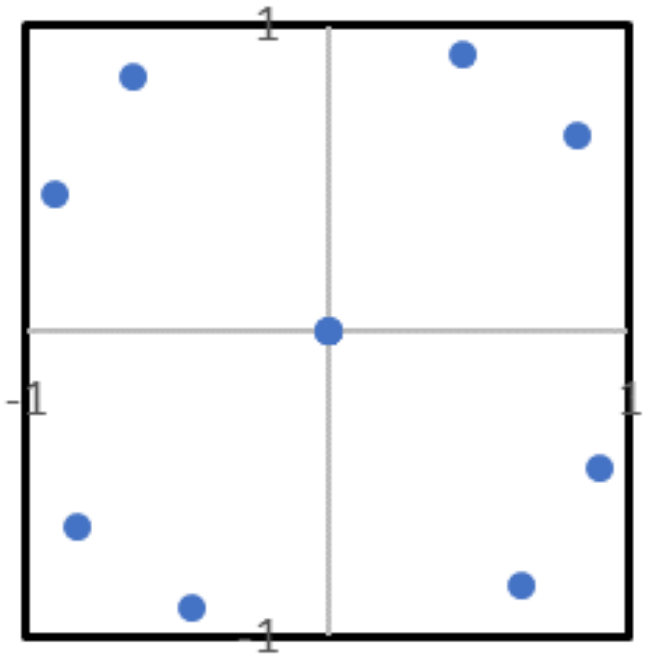
Three of the quadruplet's vertices form a nearly perfect 30-60-90 right triangle, with a twin at the right angle.

Possible connections between NuMath/Physics and the Universe (Slide 13/15)

7.5 ISL behavior from the IMSPE: Ex. 2: $N = 12, \theta_1 = \theta_2 = 0.128$



The global minimum



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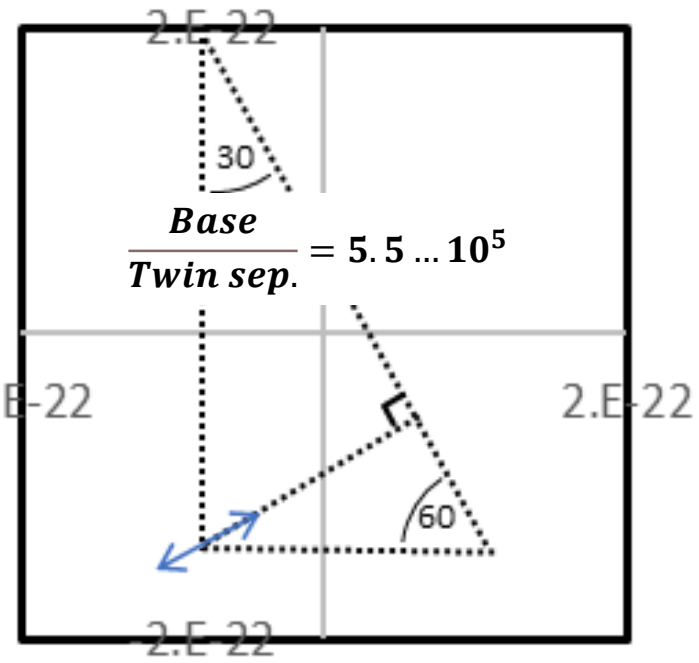
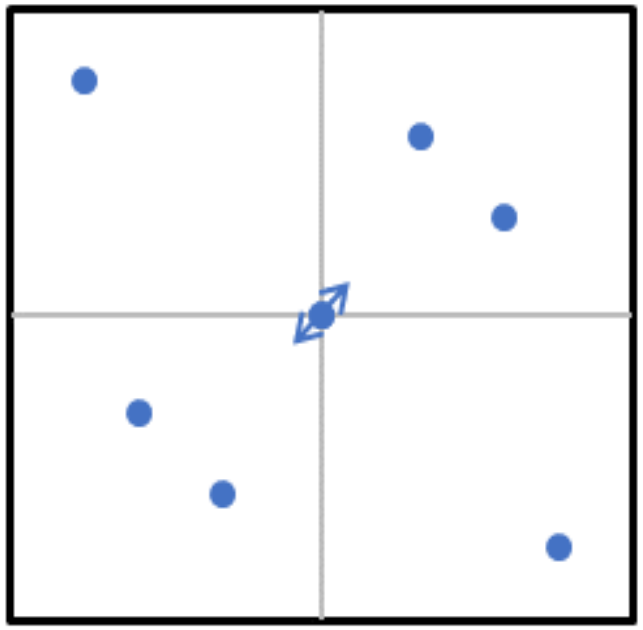
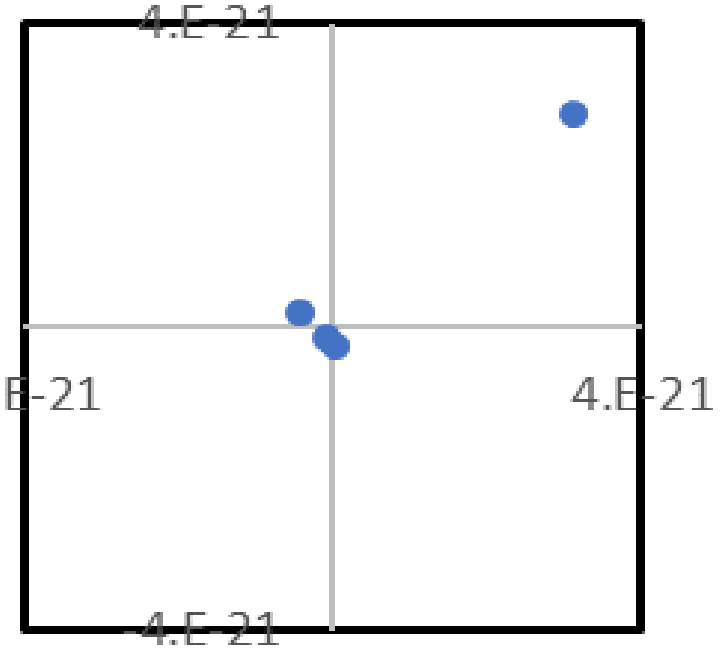


Three of the quadruplet's vertices form a nearly perfect 30-60-90 right triangle, with a twin at the right angle.

Possible connections between NuMath/Physics and the Universe (Slide 14/15)

7.6 ISL behavior from the IMSPE: Summary



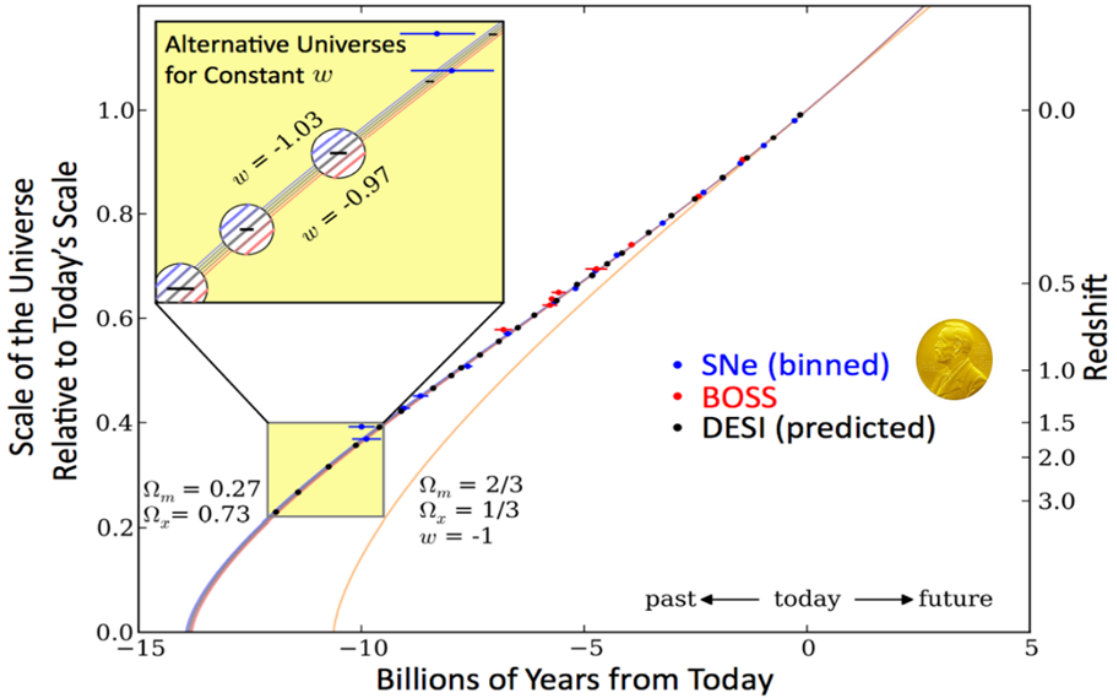


$N = 8, \theta_1 = \theta_2 = 0.03$
Ex. 1: Twin preon
Dark-matter (DM) candidate.

$N = 12, \theta_1 = \theta_2 = 0.128$: quadruplet preons:
(L) Ex. 2: Concave. (R) New Ex. 3: Convex. Are these DM candidates, or "elementary particles" of the Standard Model of Particle Physics?

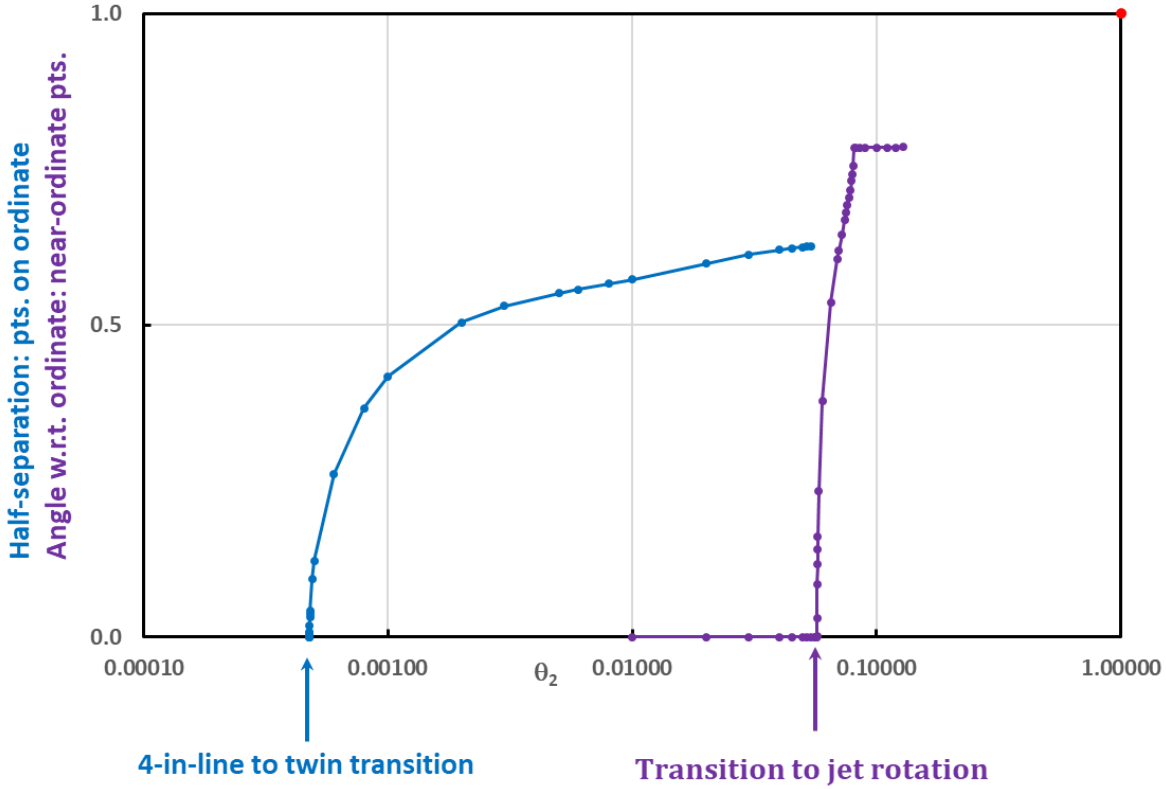
Possible connections between NuMath/Physics and the Universe (Slide 15/15)

8. Square–root cusps at continuous phase transitions



Models of the Universe's expansion display square-root cusps.

Credit: Ofer Lahav (U.C. London) talk, 2016.



Two+ continuous phase transitions of the Stormann N=4 system that display square-root cusps.

Summary of conjectures (Slide 1/3)

Emergent Nu/Math objects and effects:

Limit-zero-separation aggregates of points

Narrow, bi-conical jets of points ejected from aggregates as hyperparameters change

Web of singletons and aggregates, within which uniformity competes with aggregation

90°-bent jets

New objective-function topologies

$N_{\text{singletons}} > N_{\text{twins}} > N_{\text{larger\_aggregates}}$, almost always

Orbits closely identical to those arising from inverse-square-law, inter-particle forces

…

Summary of conjectures (Slide 2/3)

Conjectures: NuMath objects/effects correspond with the following physics:

- The Big Bang
- Jets and 90°-bent jets from active galactic nebula
- The Cosmic Web
- Formation and behavior of black holes (or fuzzballs)
- The cosmic energy budget
- Most particles in the Standard Model of Particle Physics (SMPP)
- Solar-system, galactic, and extra-galactic orbits

Key math conjecture: H=N (Hooke=Newton)

Key open questions:

- Exactly what aggregates correspond to the particles in the SMPP?
- How broadly does NuMath/Physics apply?

Summary of conjectures (Slide 3/3)

NuMath objects/effects also possibly have correspondence with the following:

Planck's constant, Speed of light, Newton's gravitational constant

Reversal of the Universe's expansion

The Universe's demise

Conformal cyclic cosmology

Multiple "island" universes

Radioactivity

…

Conclusions

Inverse-square-law forces may be emergent, rather than fundamental.

NuMath/Physics provides a new framework for possibly resolving the difficulties faced by present-day theories of physics.

Many mysteries remain ...

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