

It's all about GARY



*how Physicists
celebrate a birthday*

John Kaldjian



CONTENTS



*Memories: Gary gives Permission
to Be Creative*

*Something New: Event Chirality,
or "Handicity", and How to Sort It*

*Strange Features of the
Two Dimensional World*

*Analytic Continuation:
What Fun is THAT!*

And then, we Celebrate!

14) Exchange Degeneracy in K^+ Lambda Photoproduction.

Gary R. Goldstein, (Tufts U.) . Print-74-0854 (TUFTS), Mar 1974. 5pp.

Published in **Nucl.Phys.B79:341,1974.**

[References](#) | [LaTeX\(US\)](#) | [LaTeX\(EU\)](#) | [Harvmac](#) | [BibTeX](#) | Cited [1 time](#)

Journal Server [doi:[10.1016/0550-3213\(74\)90491-X](#)]

[Bookmarkable link to this information](#)

15) Optimally Simple Connection Between the Reaction Matrix and the Observables.

Gary R. Goldstein, (Tufts U.) , Michael J. Moravcsik, (Oregon U.) . PRINT-74-0982 (OREGON), May 1974. (Published 54pp.

Published in **Annals Phys.98:128,1976.**

TOPCITE = 50+

[References](#) | [LaTeX\(US\)](#) | [LaTeX\(EU\)](#) | [Harvmac](#) | [BibTeX](#) | [Keywords](#) | Cited [62 times](#)

Journal Server [doi:[10.1016/0003-4916\(76\)90241-4](#)]

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16) Semilocal Duality in π^0 Photoproduction.

H.K. Armenian, Gary R. Goldstein, J.P. Rutherford, D.L. Weaver, (Tufts U.) . PRINT-74-1685 (TUFTS), Sep 1974. 15p

Published in **Phys.Rev.D12:1278,1975.**

[References](#) | [LaTeX\(US\)](#) | [LaTeX\(EU\)](#) | [Harvmac](#) | [BibTeX](#) | [Keywords](#) | Cited [1 time](#)

Journal Server [doi:[10.1103/PhysRevD.12.1278](#)]

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Gary and Mike:

Experiments that average over observable information,

like spin, don't really tell you much:

they don't test much, and they tend to confirm wrong theory



"gary goldstein" physics

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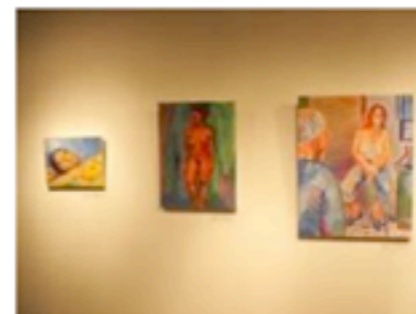
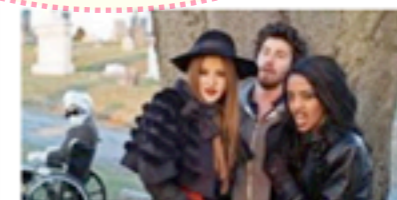
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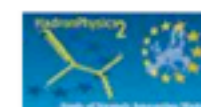
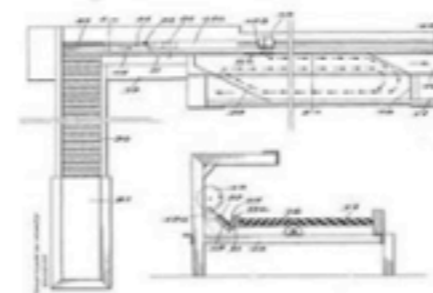
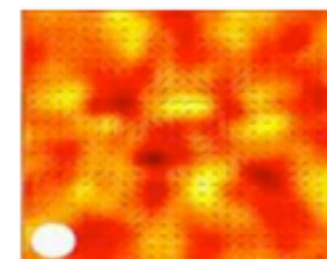
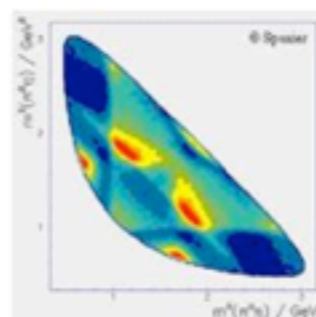


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THE WINNER IS...





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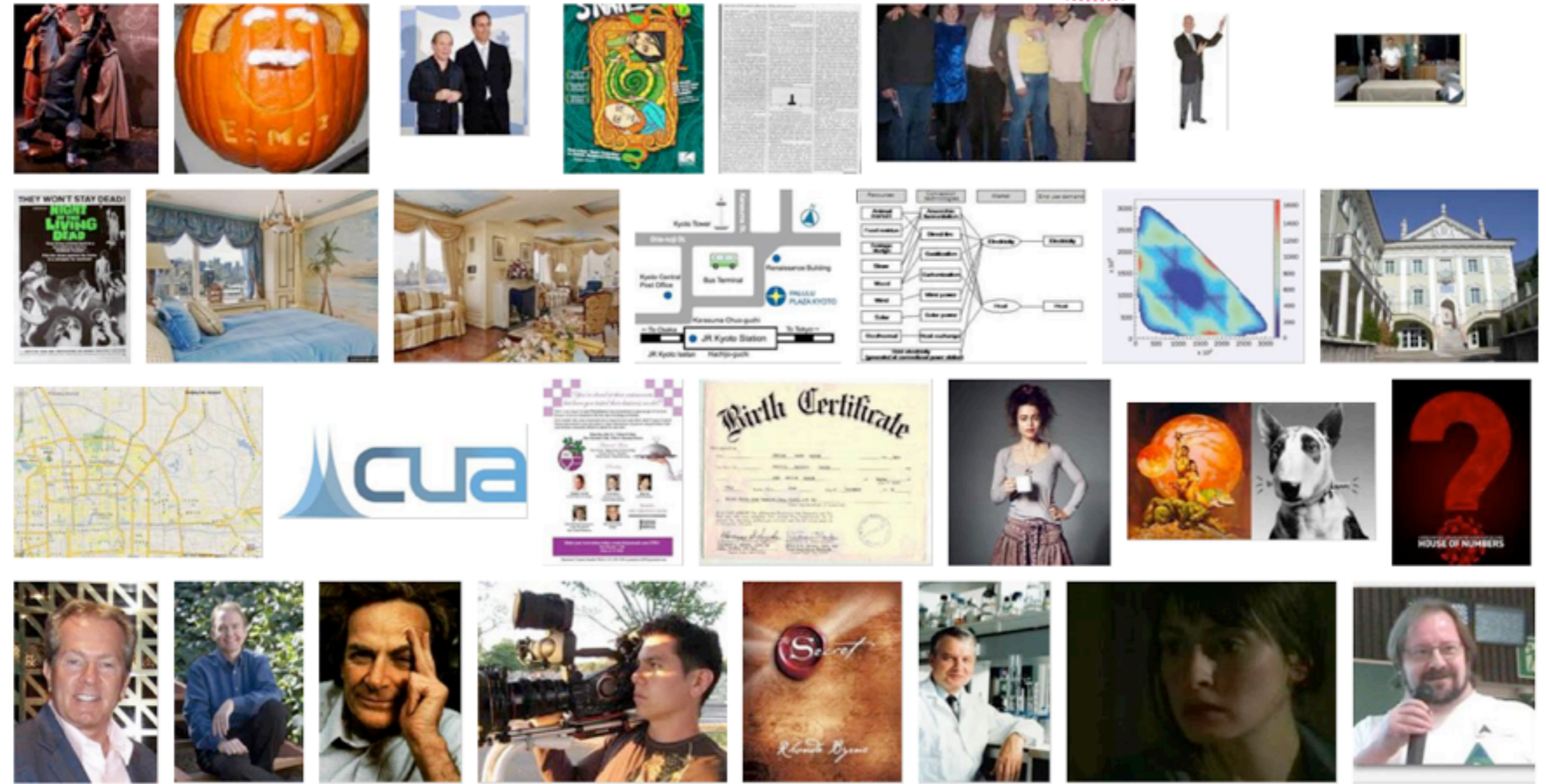
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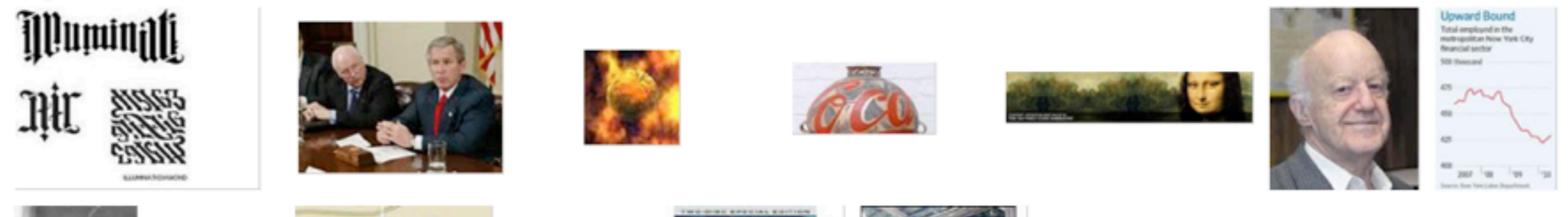
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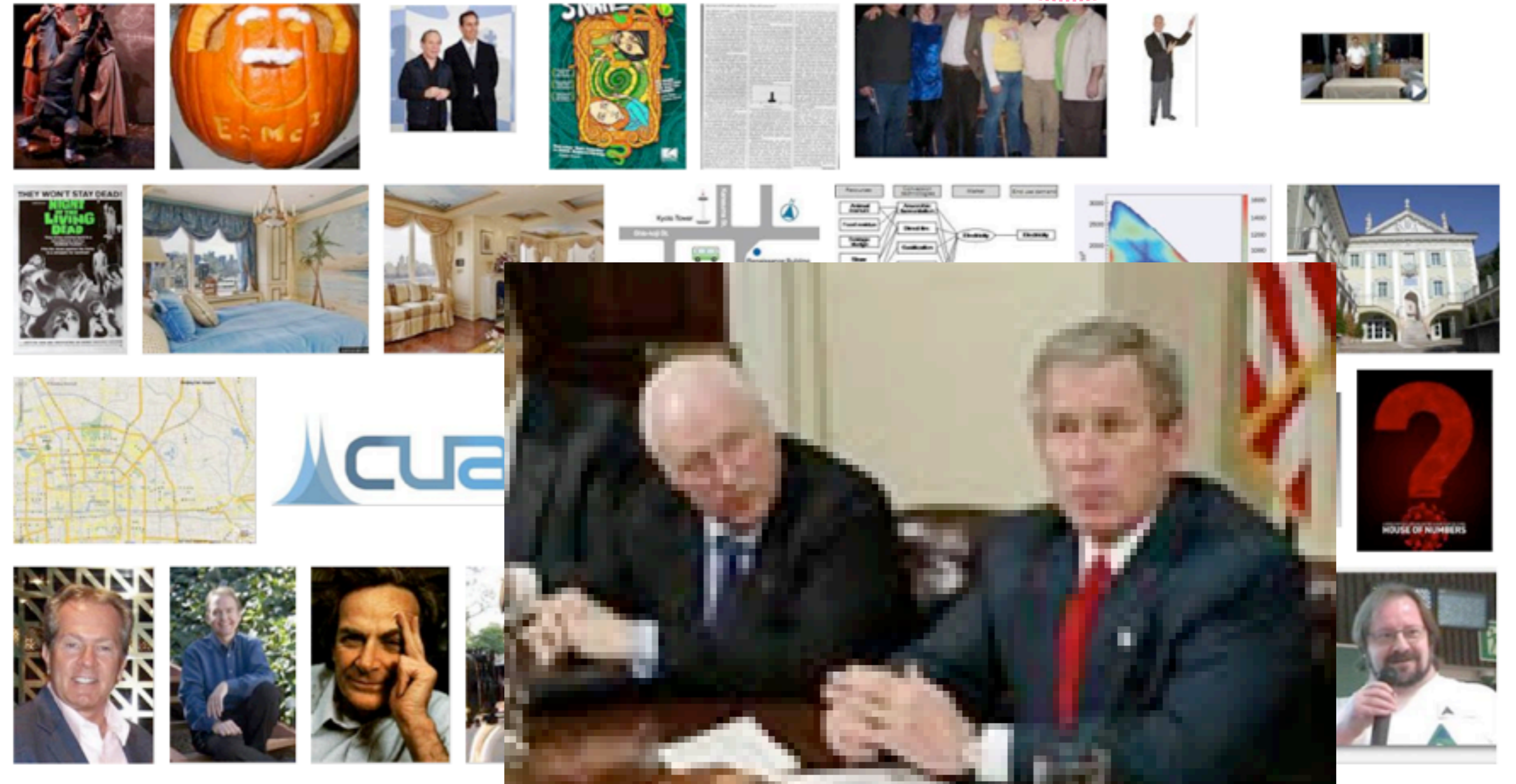
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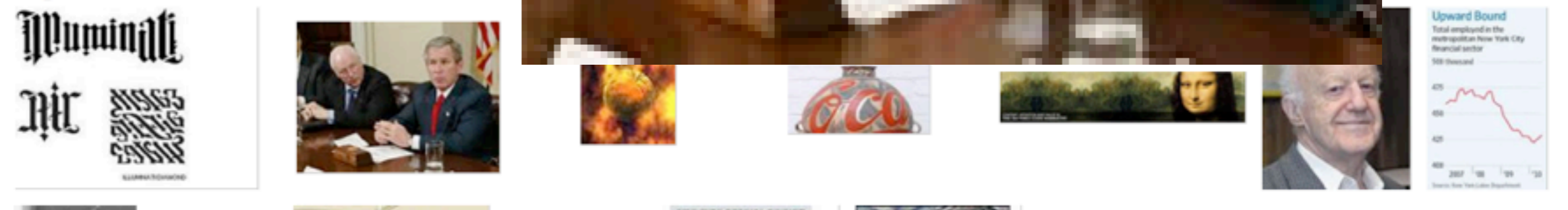
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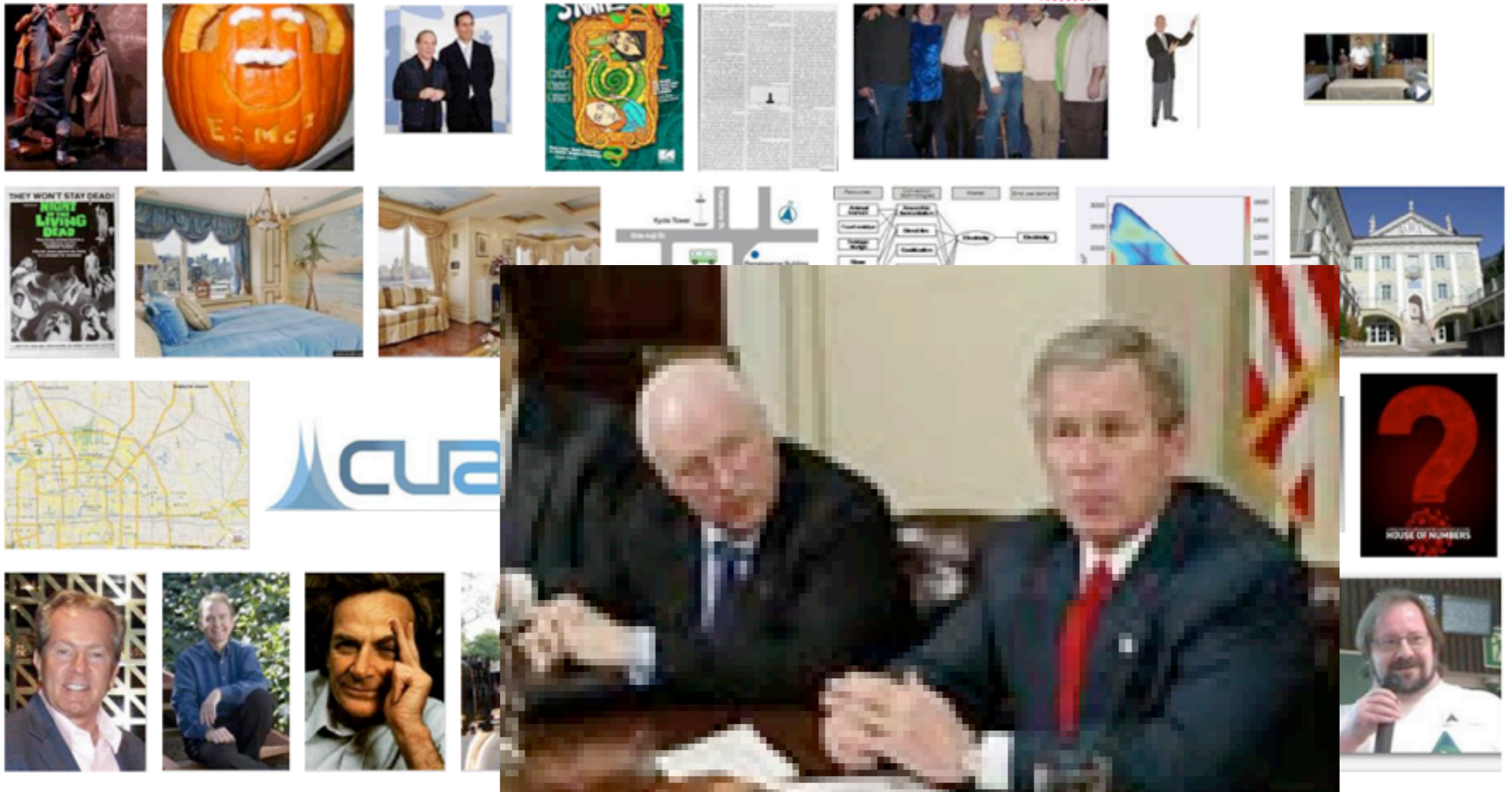
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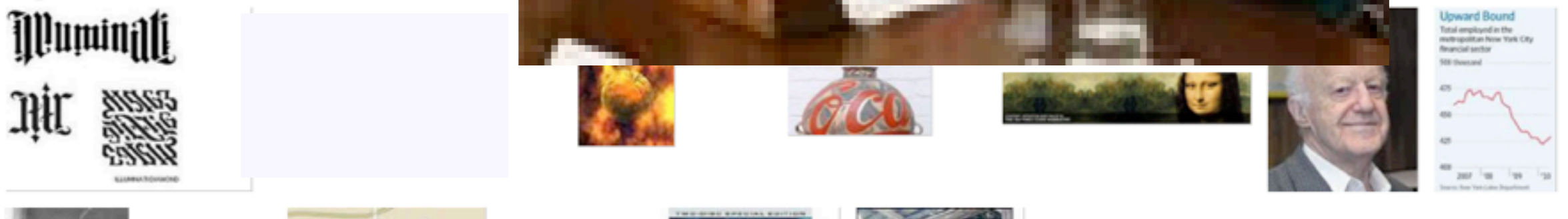
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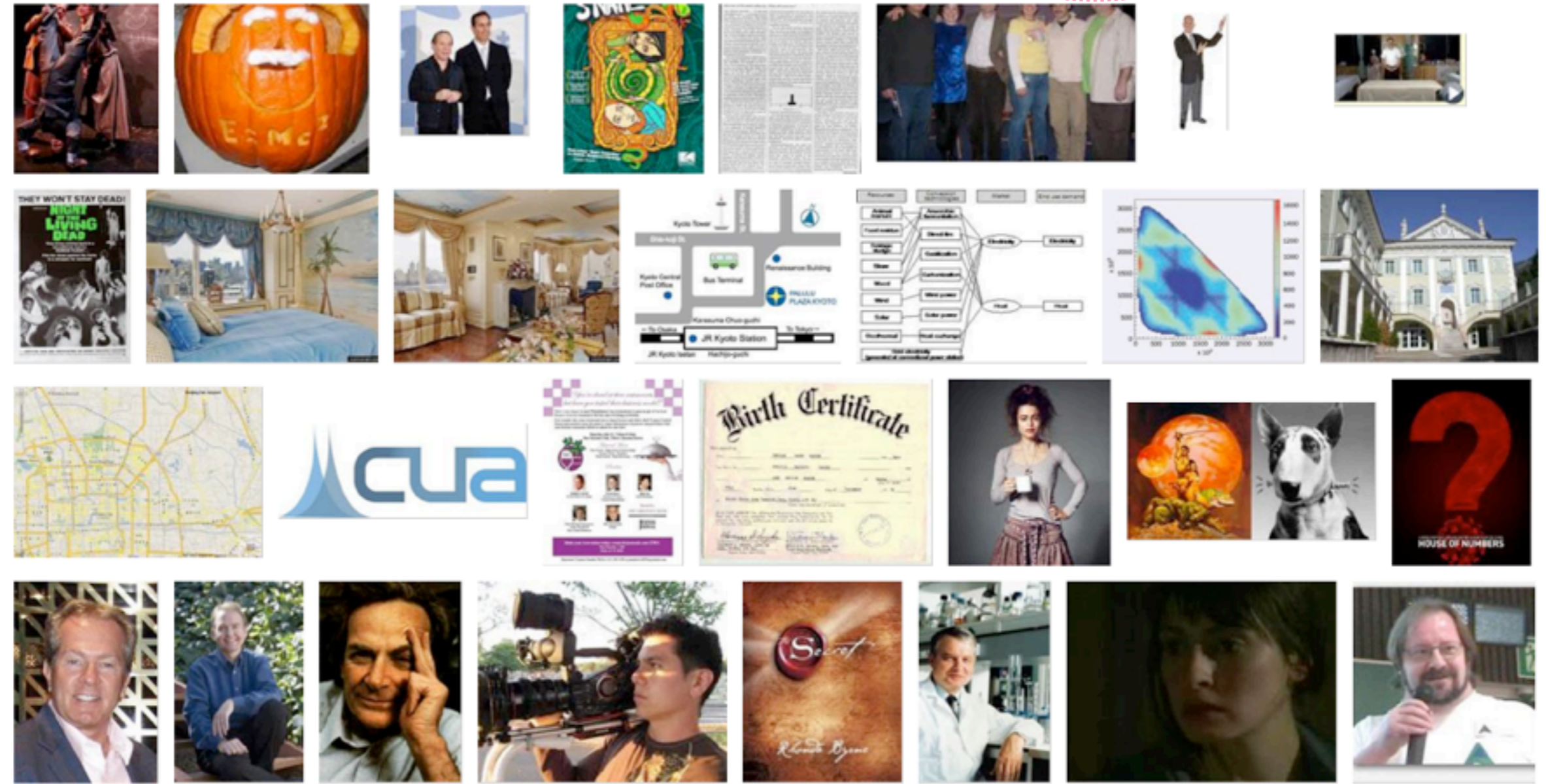
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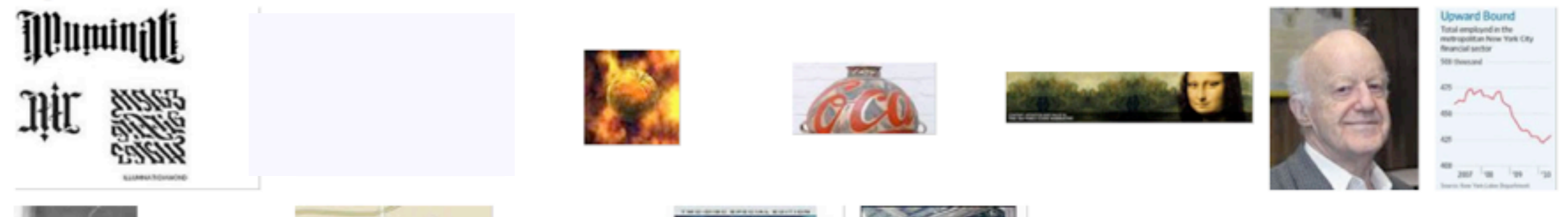
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The Garry Effects:



we think a party is... *Doing Physics*



it's more than OK to
think about *SPIN*



Always break azimuthal symmetry
(there's so much to learn)



we think a party is ...Doing Physics...

*Let's talk about...
event-by-event
parity, chirality,
"handicity"*



*work with Mihailo
BACKOVIC*

Let's talk about event-by-event parity

$$D \in O(3); \quad \det D = -1$$

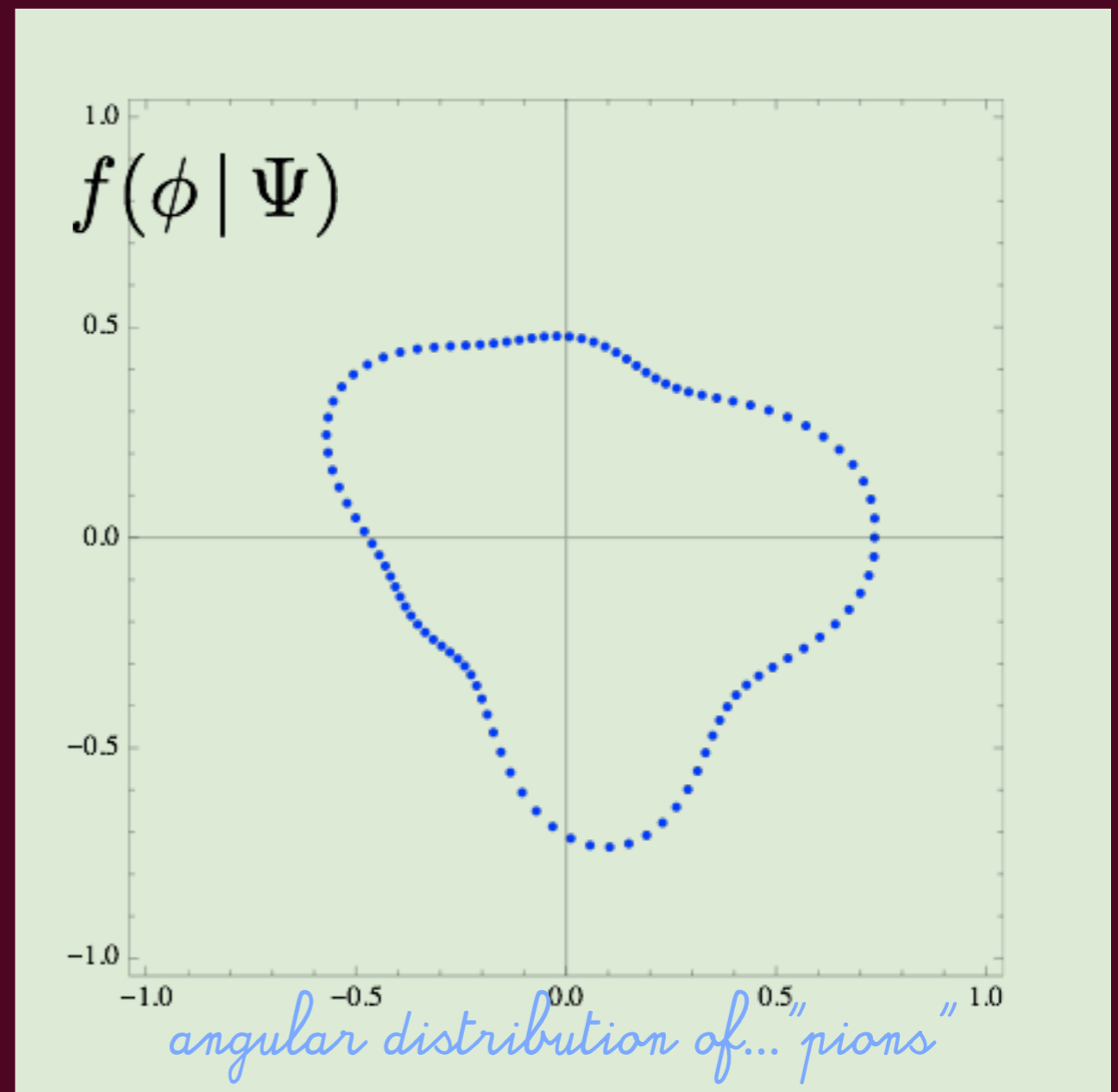
$$f(\phi) = \frac{dN}{d\phi}$$

$$f(\phi, \Psi) = \frac{dN}{d\phi d\Psi}$$

$$f(\phi, \Psi) = f(\phi | \Psi) f(\Psi)$$

for RHIC physics;
Voloshin et al

Every event breaks parity symmetry



parity is NOT cosine/sine separation - that's origin-dependent

$$\frac{dN}{d\phi} = \frac{1}{2\pi} + \overset{\text{"even"}}{v \cos \phi} + \overset{\text{"odd"}}{a \sin \phi};$$

Let $v = \rho \cos \Psi;$ $a = \rho \sin \Psi;$

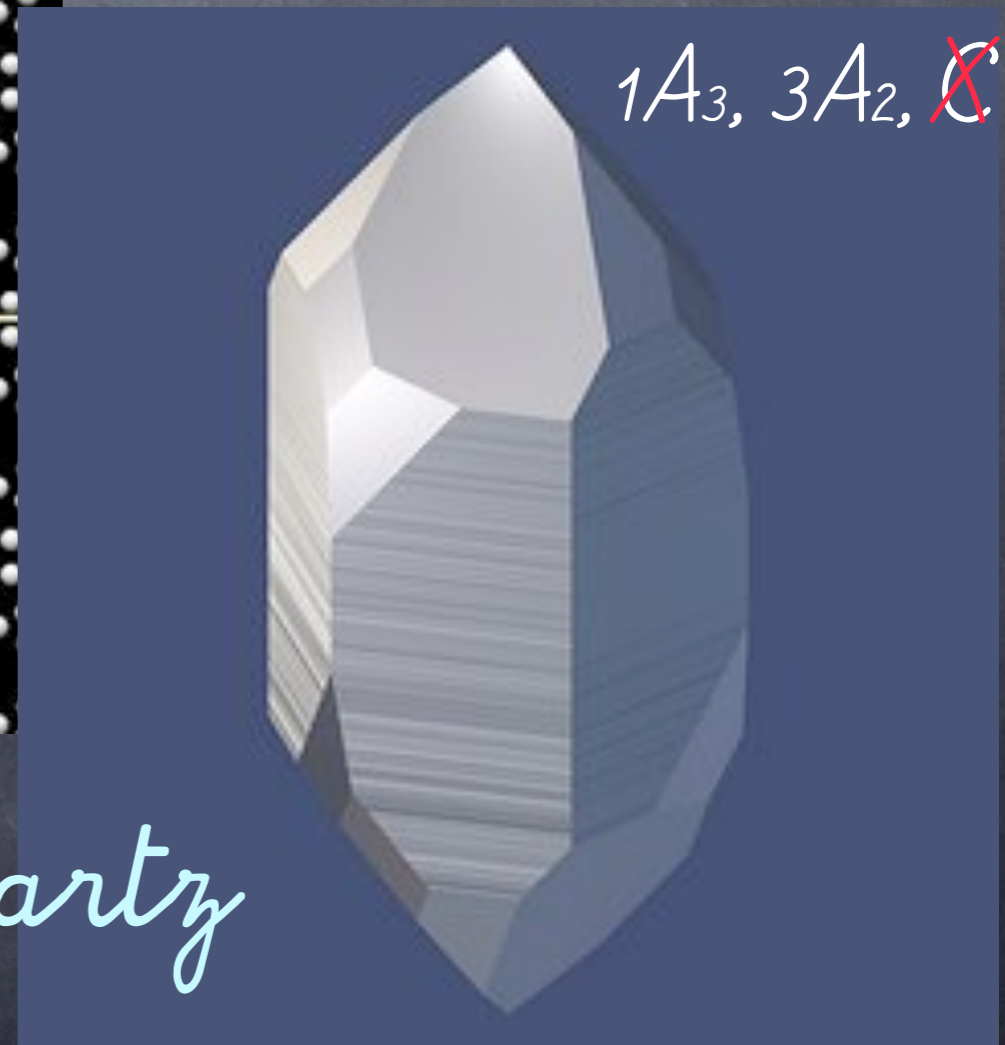
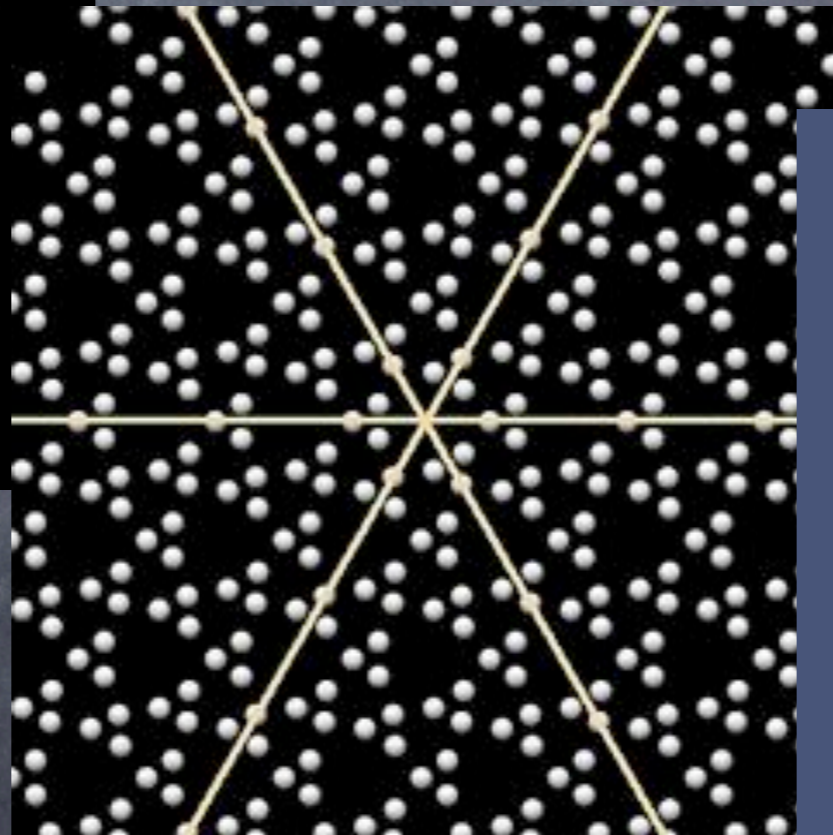
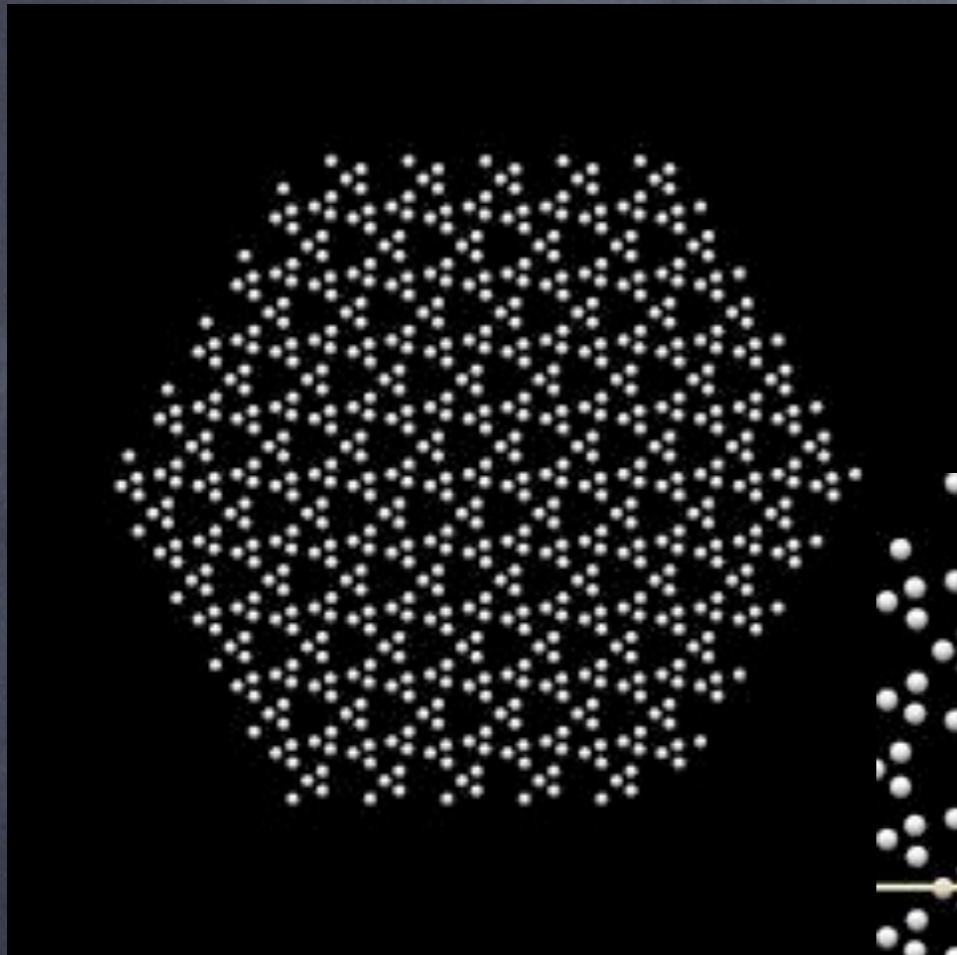
then $\frac{dN}{d\phi} = \frac{1}{2\pi} + \overset{\text{"even"}}{\rho \cos(\phi - \Psi)}$

measures nothing about parity:
STAR experiment

parity and event chirality have been overlooked...

spontaneous parity violation is **COMMON** in Nature,
even macroscopically

$$f(\text{object} \mid \text{chirality}) \neq 0$$

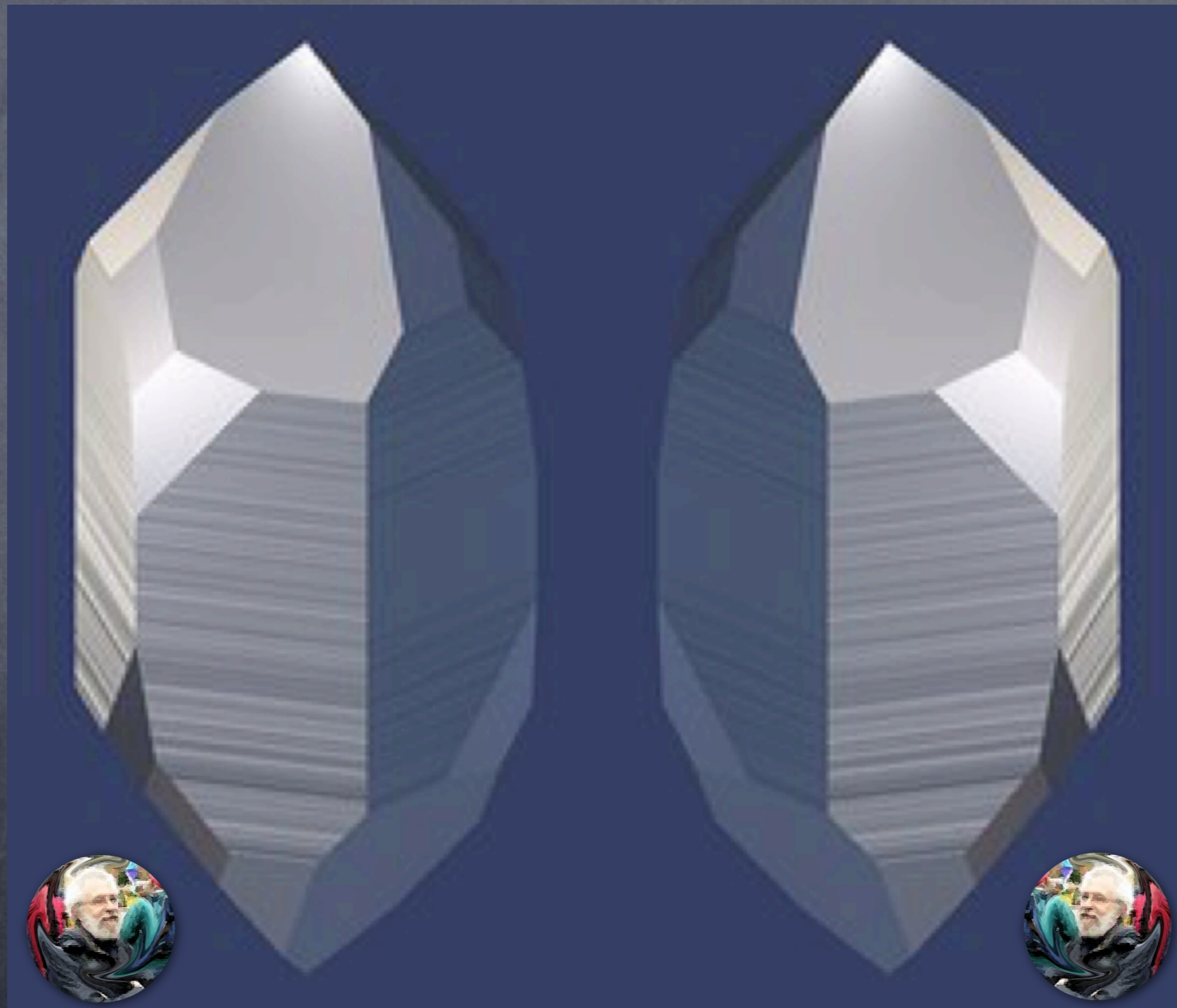


[/www.quartzpage.de](http://www.quartzpage.de)


quartz

left and right handed quartz, SiO_2

the unsorted,
global, angle and
chirality
AVERAGED
crystal is a...ball



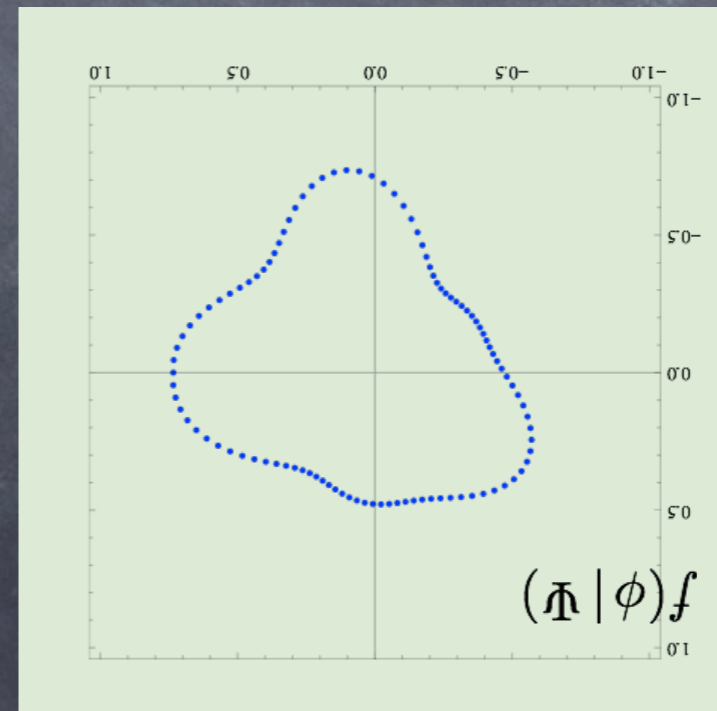
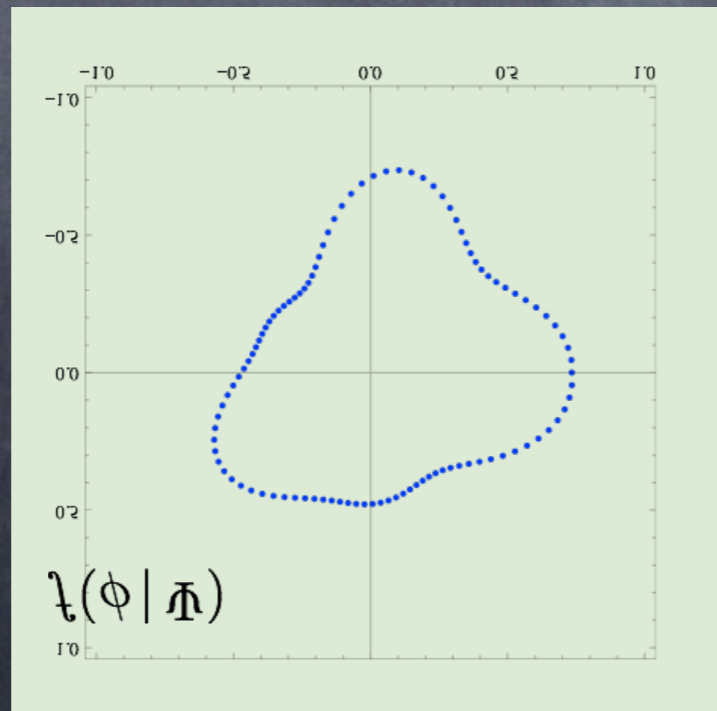
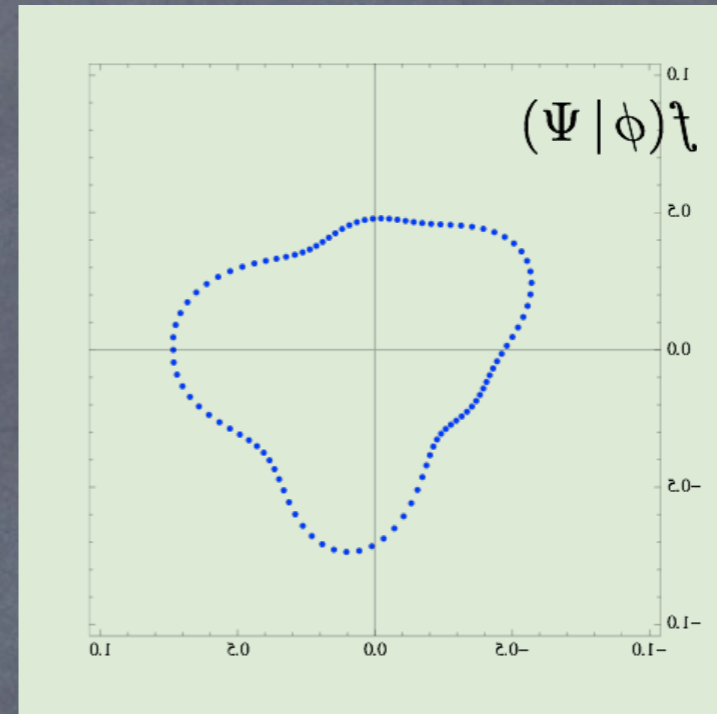
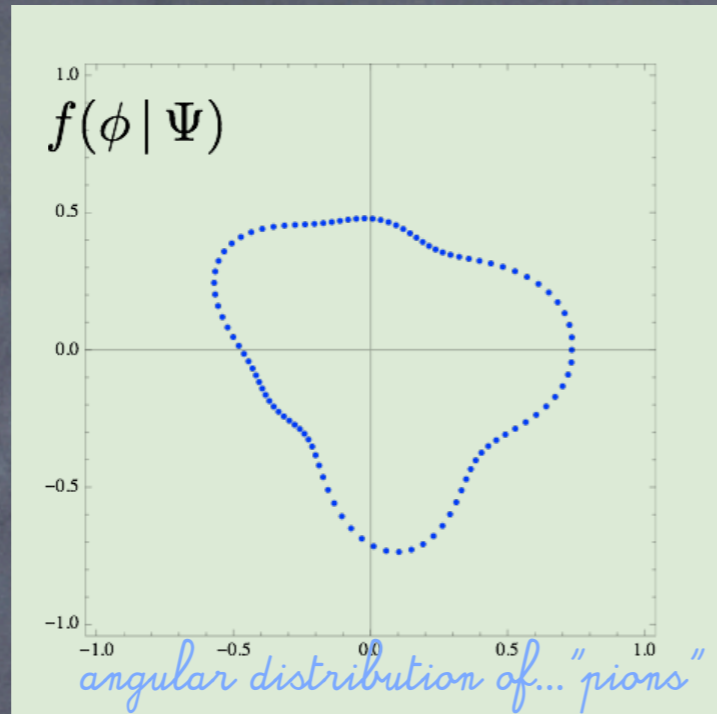
sort first;
average
afterwards

A close-up photograph of a person's hand holding a small, white, rectangular box. The box is filled with several clear, crystalline mineral specimens. The hand is positioned on the left side of the frame, with the thumb and index finger gripping the top edge of the box. A gold ring is visible on the ring finger. The background is a blurred outdoor setting with green foliage and a path. The lighting is bright, suggesting a sunny day.

SELENITE 4.00
KANAPOLIS, KS,



“chirality sorting”: four events conditional on orientation



first sort,
then add
events

Violating 2D parity violates 3D parity

Consider any $D \in O(3)$ with $\det(D) = -1$. If symmetry of the Hamiltonian H under D fails then $[H, D] \neq 0$. In three dimensions parity $P = -1_{3 \times 3}$. From D make a pure rotation $R = P D$, $\det(R) = 1$. Then

$$[H, D] = [H, P R] = P[H, R] + [H, P]R \neq 0,$$

or

$$[H, P] \neq 0,$$

given rotational invariance $[H, R] = 0$. Then P -symmetry is violated by finding *any single case of parity-violation on a subspace*.

Yet 2D parity is far more complicated...

3 dimensions

$$\vec{x} \xrightarrow{P} -\vec{x}$$

$$\det \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix} = -1$$

2 dimensions

$$\vec{x} \xrightarrow{?} -\vec{x}$$

$$\det \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} = +1 \quad \text{this is a rotation}$$

There DOES NOT EXIST a rotationally invariant parity
on TWO dimensional space

D_N , the dihedral groups of index N ,
form the discrete subgroups of $O(2)$

generator algebra:

$$\mathcal{R}^N = 1, \quad \mathcal{P}^2 = 1, \quad \mathcal{P}\mathcal{R}\mathcal{P} = \mathcal{R}^{-1}$$

$2N$ elements (R_{Nk}, P_{Nk}) , for $k = (0 \dots N - 1)$,

$$\text{with } \det(R_{Nk}) = 1, \quad \det(P_{Nk}) = -1$$

non-Abelian: no P_{Nk} commutes with any R_{Nk}

all previous measures of 2D "chirality" in computer science, image
processing...psychology...either fail under D_N or $SO(2)$

D_N elements: $k=0\dots N-1$

$$P_{Nk} = \begin{pmatrix} \cos 2\pi k/N & \sin 2\pi k/N \\ \sin 2\pi k/N & -\cos 2\pi k/N \end{pmatrix};$$

$$R_{Nk} = \begin{pmatrix} \cos 2\pi k/N & -\sin 2\pi k/N \\ \sin 2\pi k/N & \cos 2\pi k/N \end{pmatrix}.$$

*how shall we measure and sort
the degree of chirality in two dimensions?*



the whirlyness of the classical distribution...

$$\int_0^{2\pi} d\phi f\left(-i\frac{\partial}{\partial\phi}\right)f \quad \dots\text{equals zero.}$$

In quantum mechanics...

$$\int_0^{2\pi} d\phi \psi^* \left(-i\frac{\partial}{\partial\phi}\right)\psi \neq 0$$

2D rotationally invariant; DN (even, odd)

to get ψ from f ... analytically continue

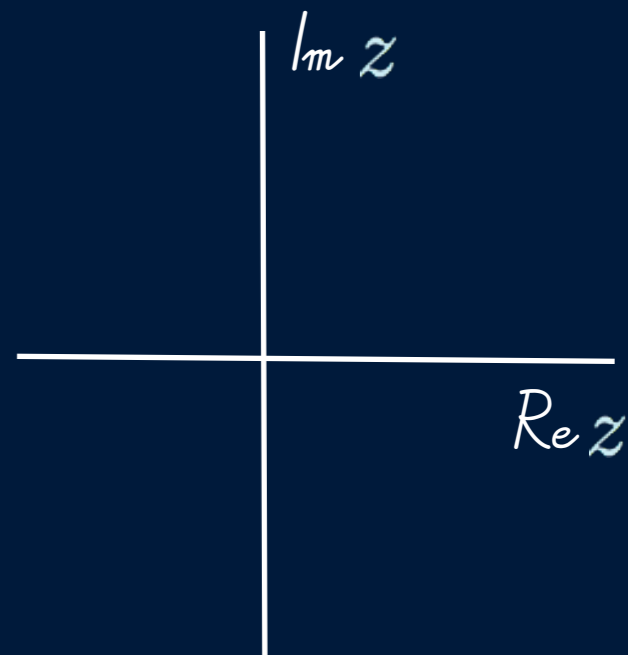


Analytic continuation: $z = e^{i\phi}$

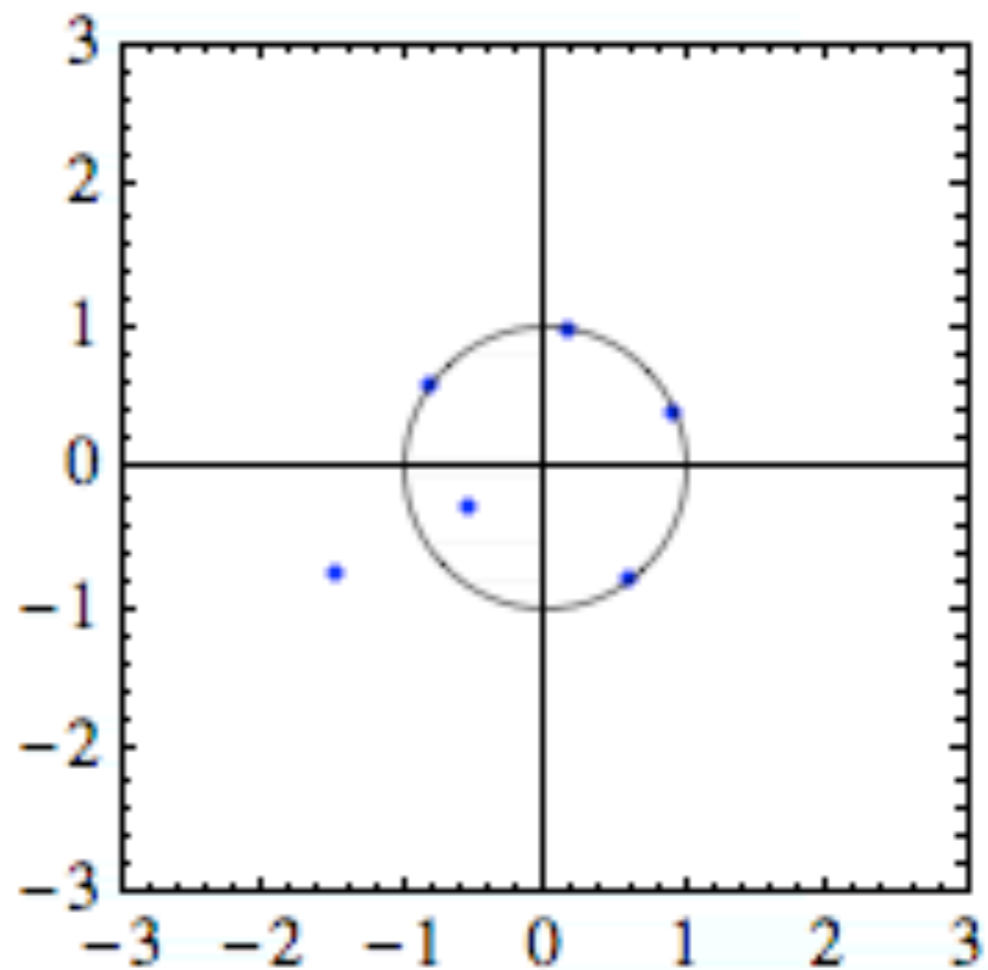
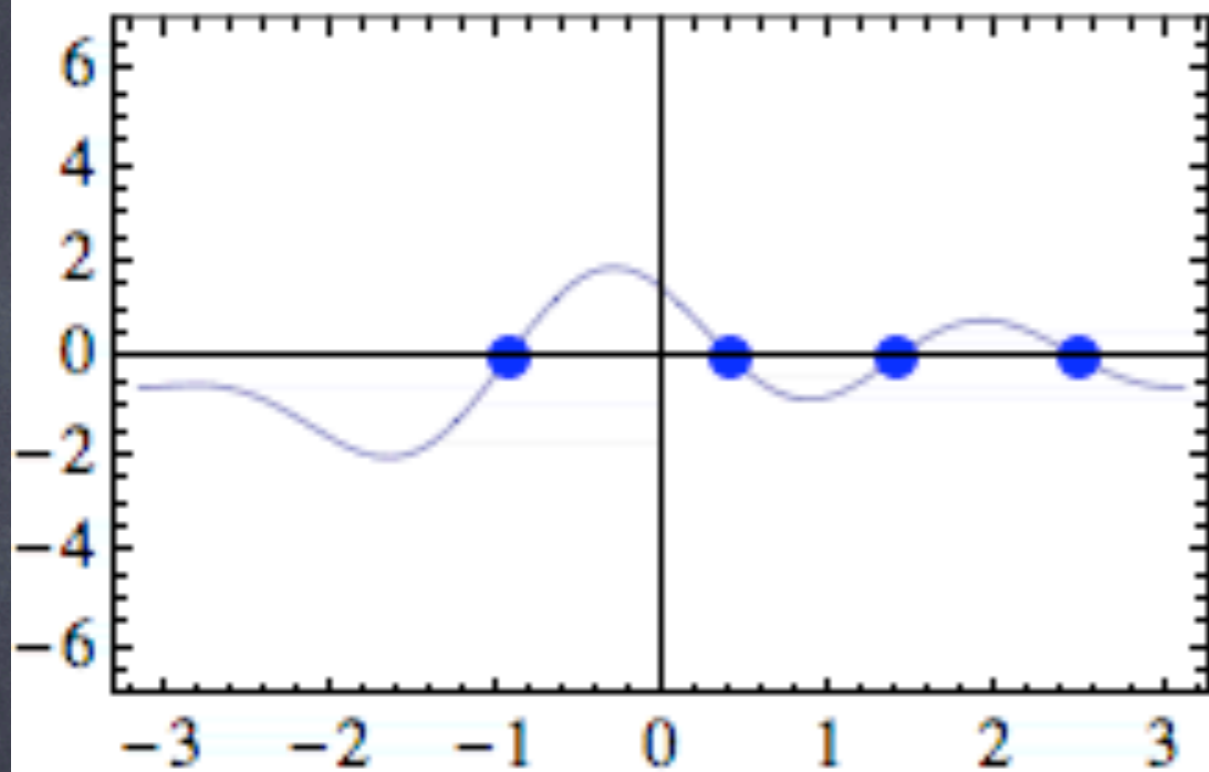
$$f(\phi) = \sum_{m=-\ell}^{\ell} f_m e^{im\phi} = z^{-\ell} \sum_{m=0}^{2\ell} f_m z^m,$$
$$= f_0 z^{-\ell} \prod_{k=1}^{2\ell} (z - z_k).$$

poles and zeroes

"fundamental
theorem of
algebra"



under rotations, complex zeros transform
like 2-vectors



*under rotations, complex zeros transform
like 2-vectors*

Continuation, continued:

$$\begin{aligned} f(\phi) &= \sum_{m=-\ell}^{\ell} f_m e^{im\phi} = z^{-\ell} \sum_{m=0}^{2\ell} f_m z^m, \\ &= f_0 z^{-\ell} \prod_{k=1}^{2\ell} (z - z_k). \end{aligned}$$

$f(\phi) = \text{real} \rightarrow \text{zeroes in pairs } (z_k, 1/z_k^*)$

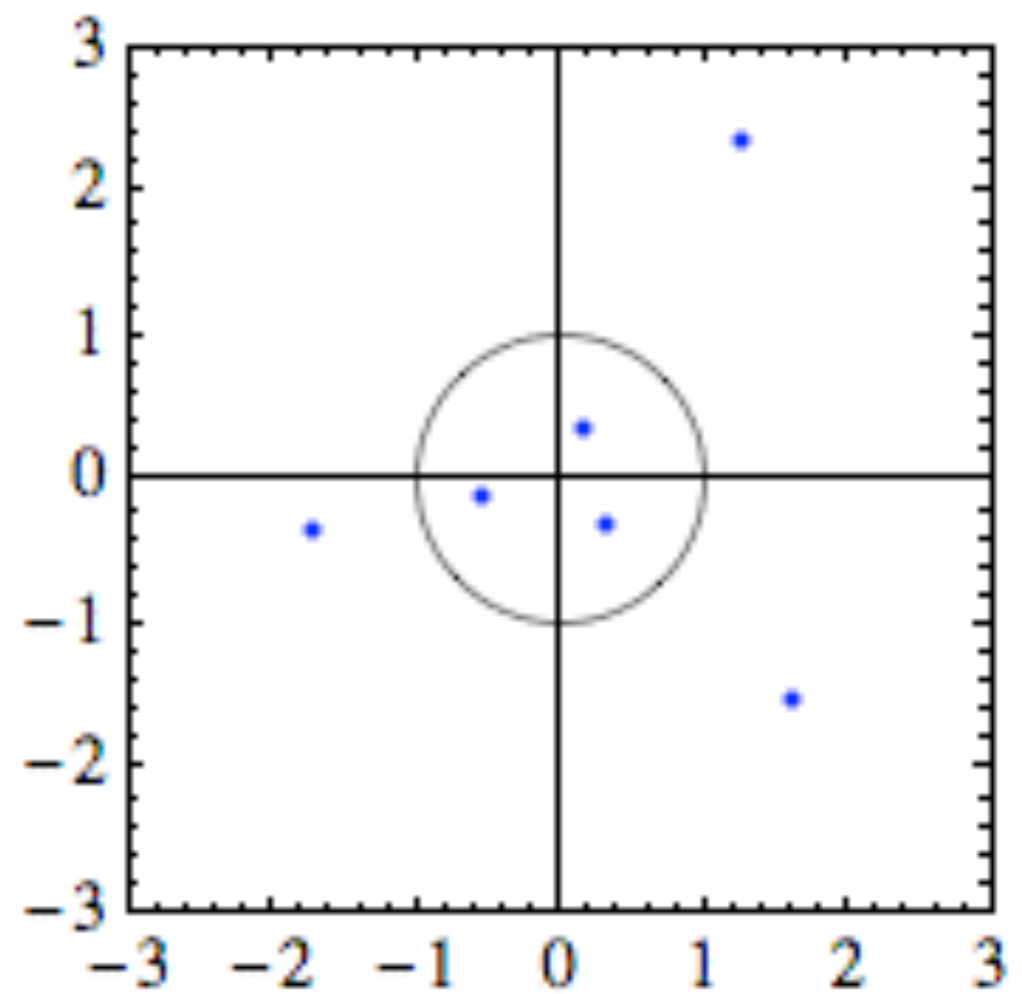
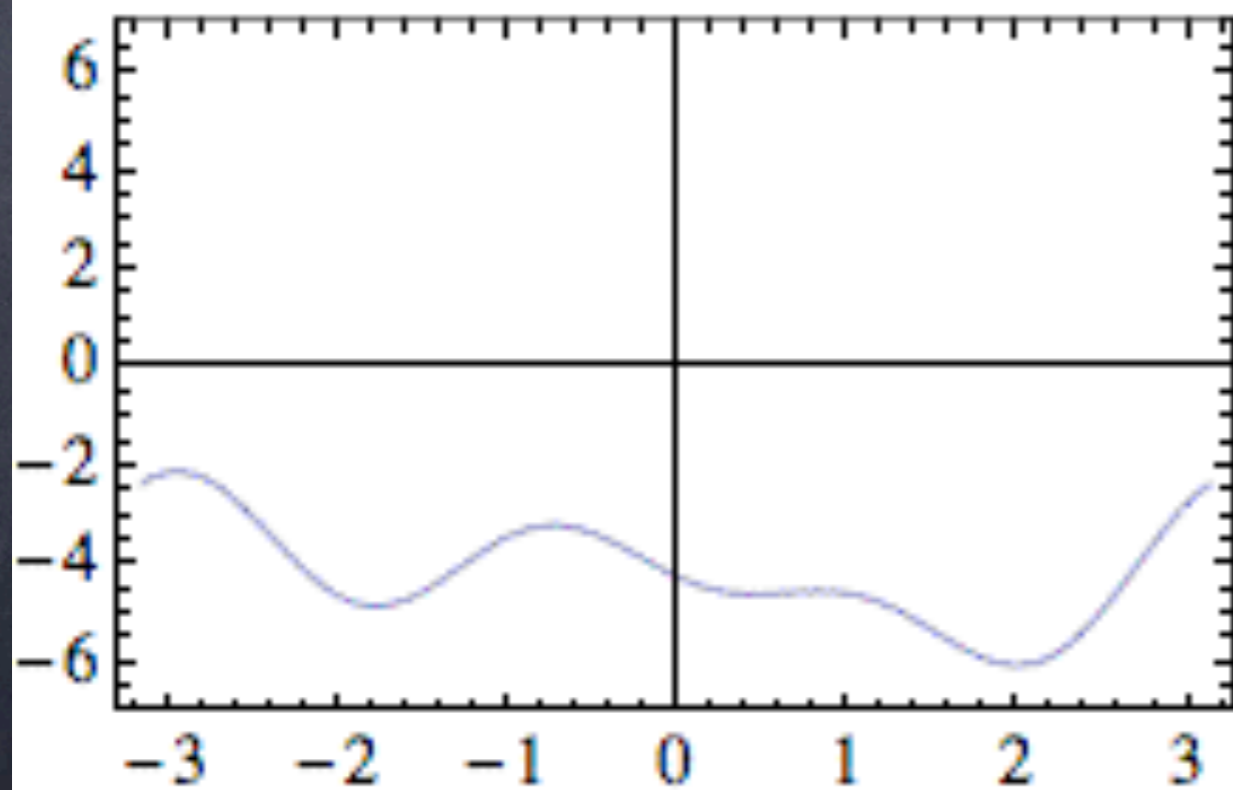
$$f(z; |z| = 1) = \psi(z)^* \psi(z)$$

where
$$\psi(z) = \psi_0 \prod_k^{\ell} \frac{z - z_k}{z}$$

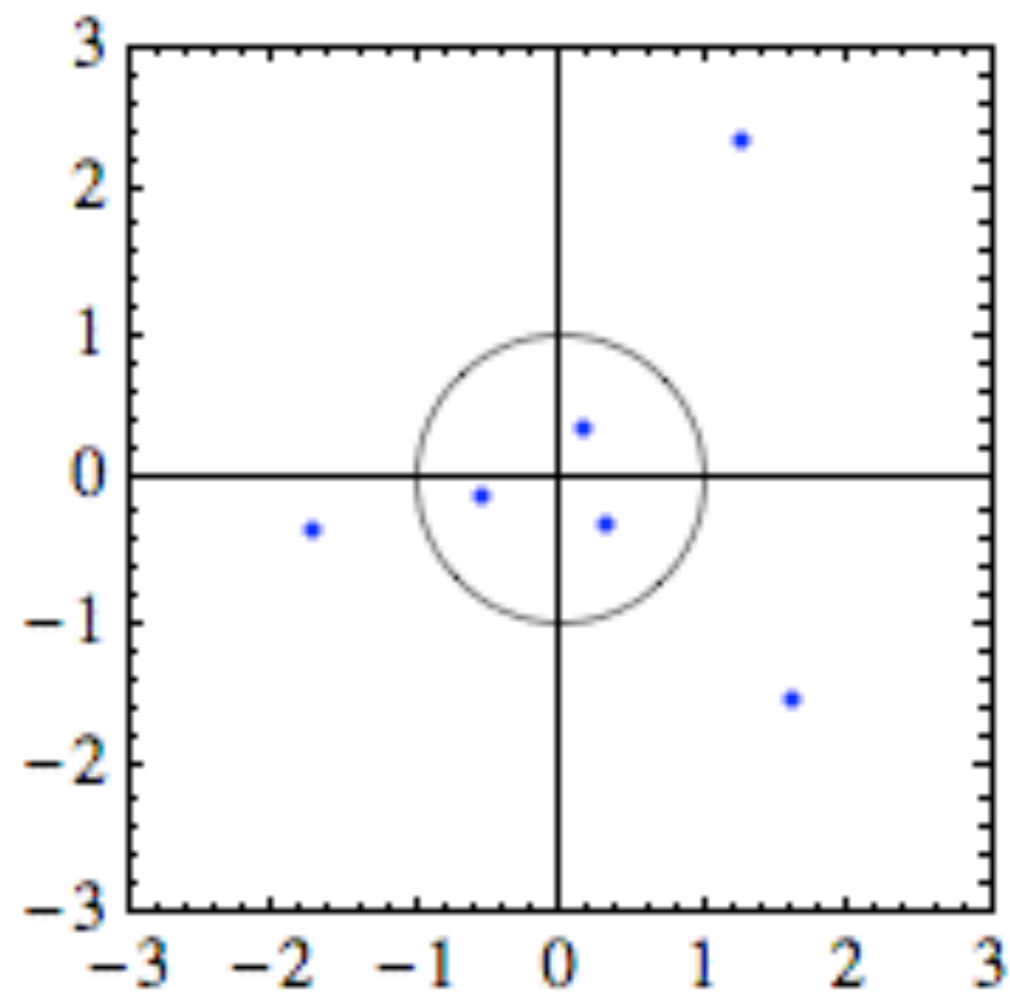
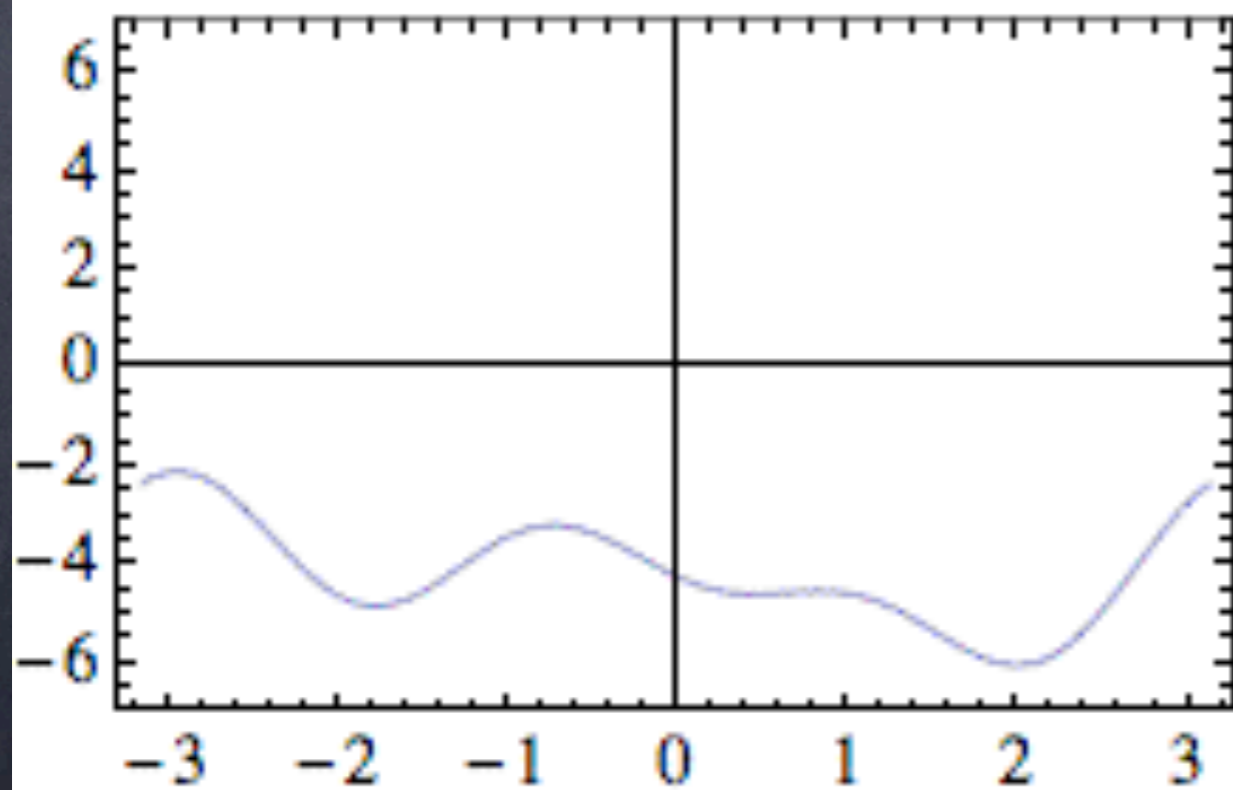
note, with symmetric singularities at zero

adding a constant:

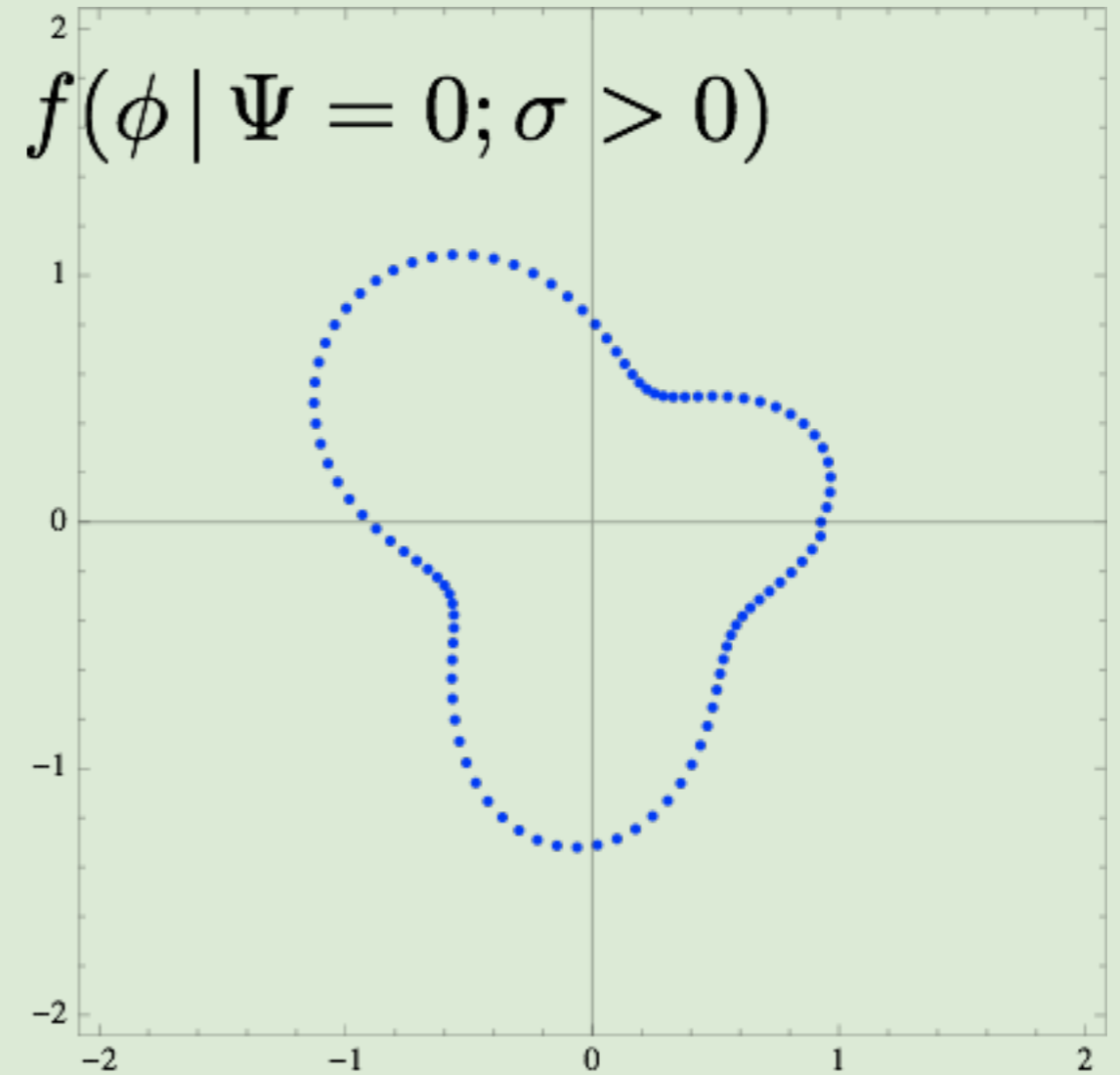
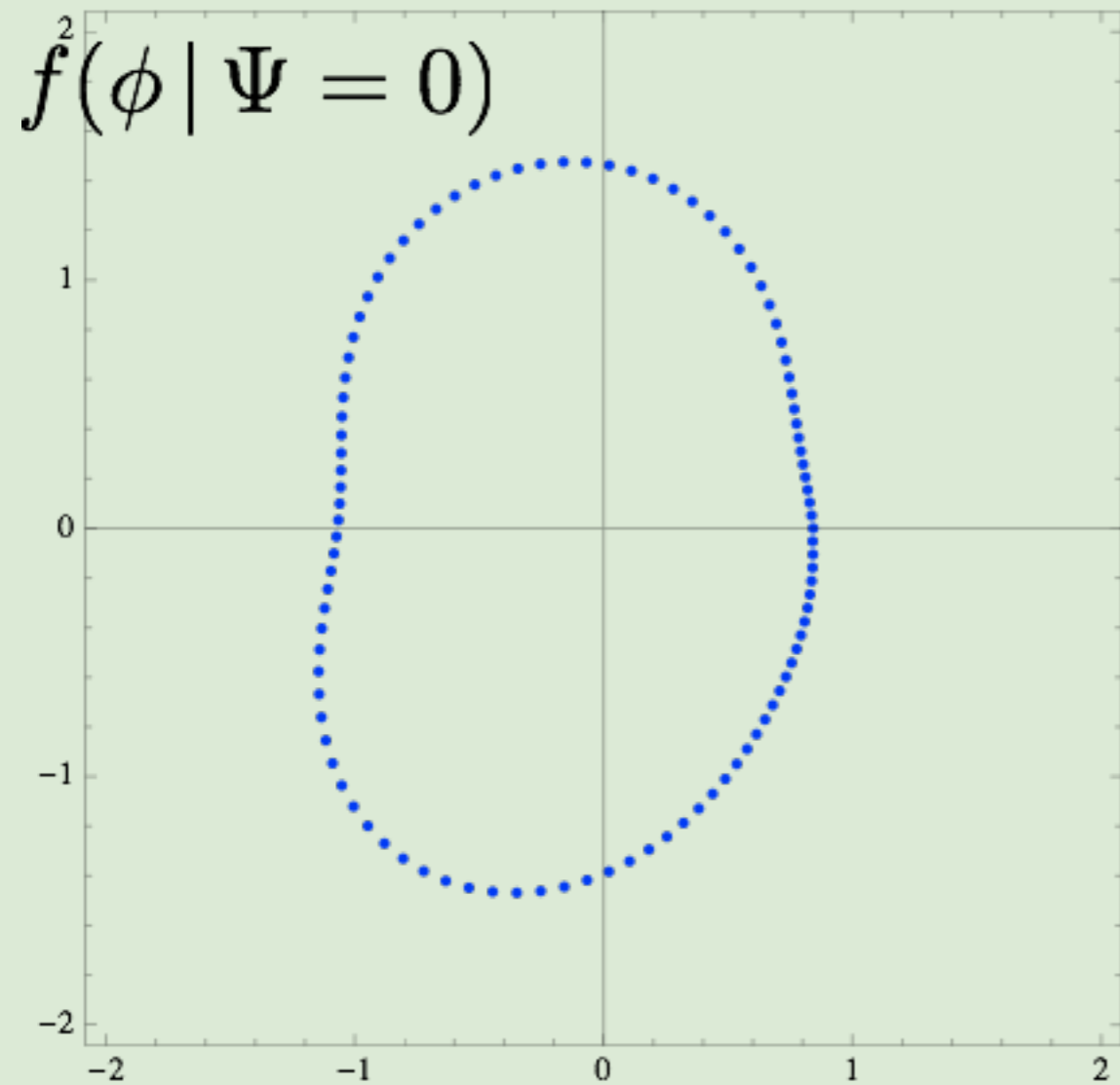
adding a constant:



adding a constant:



a test run, cutting on handicapity

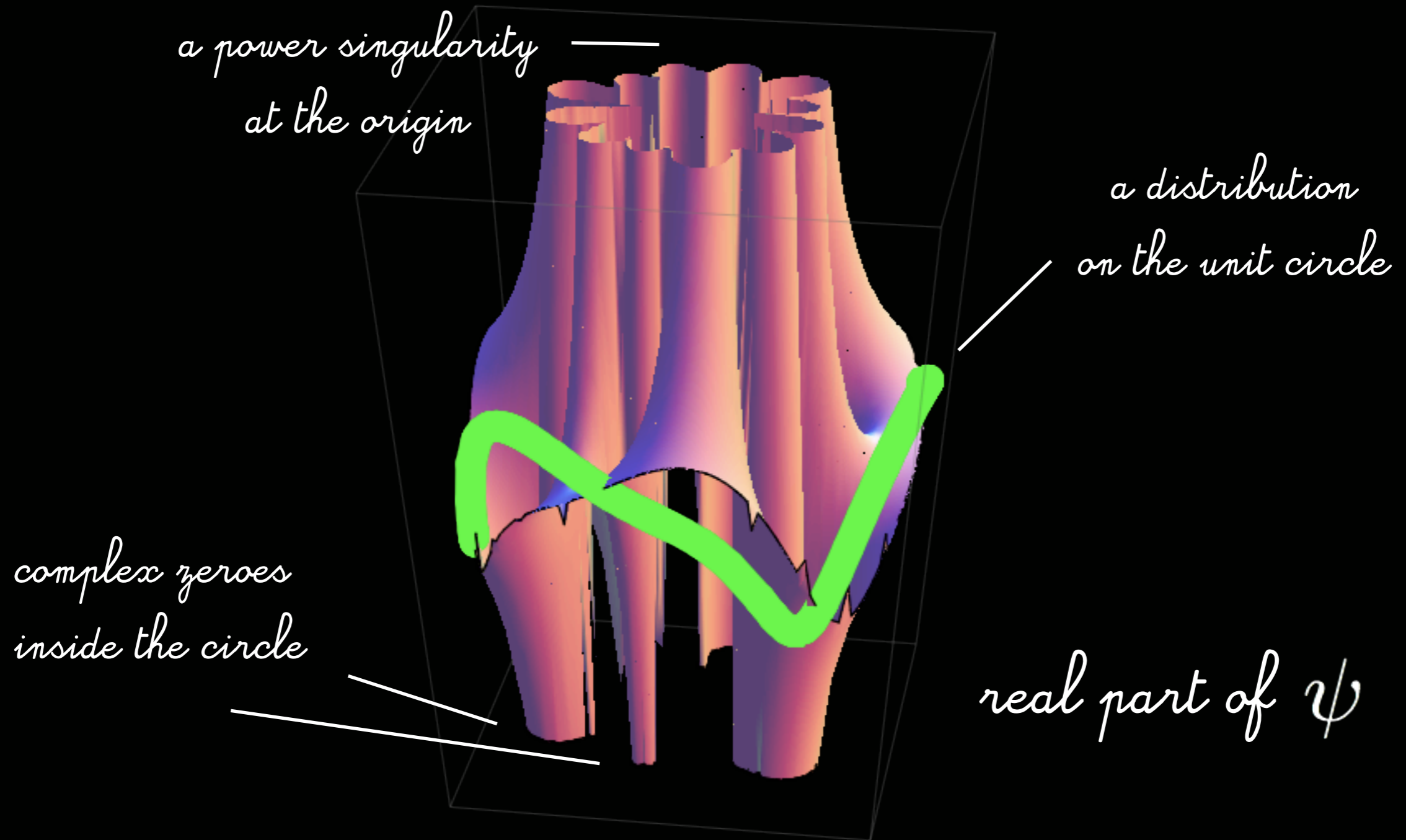




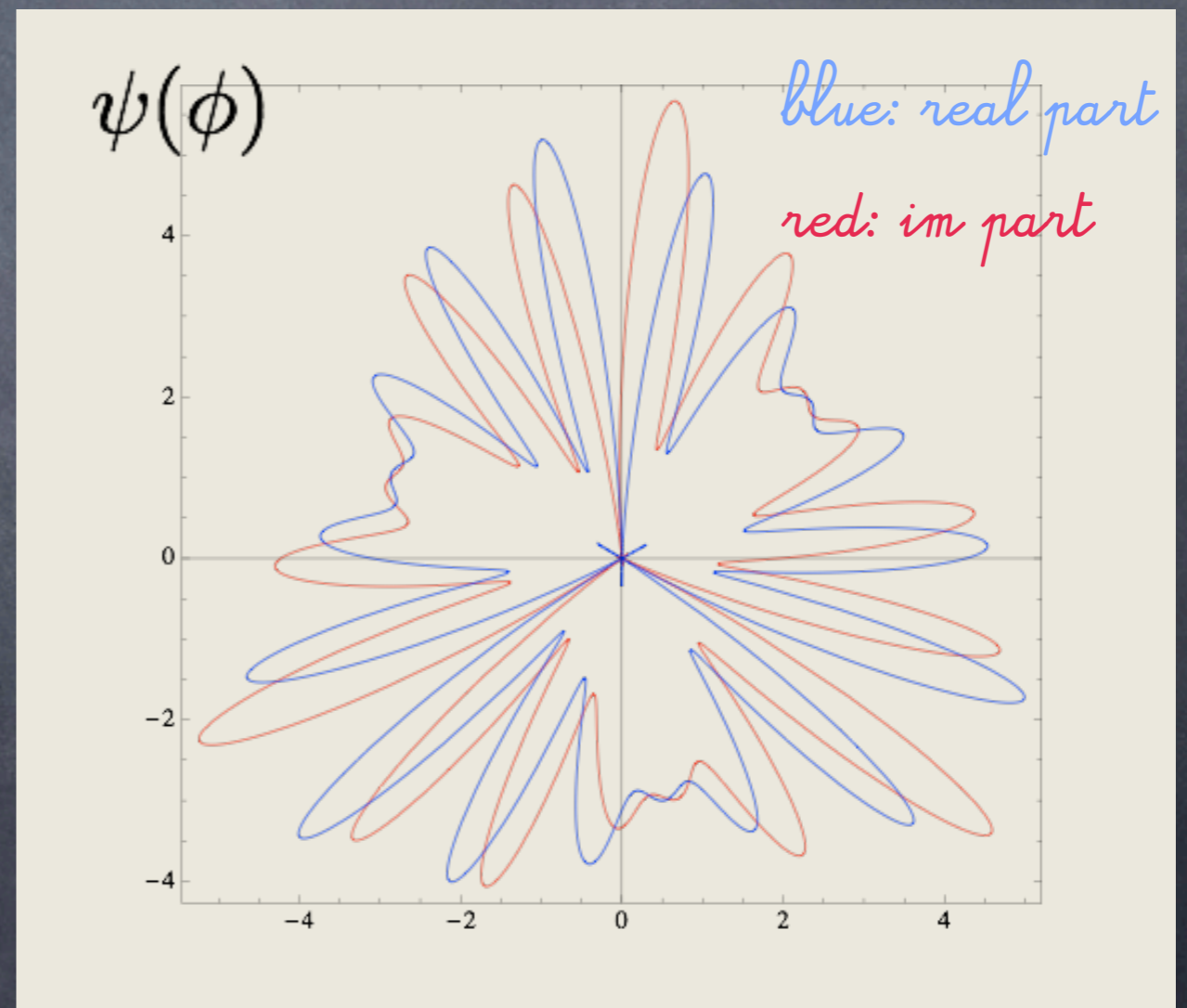
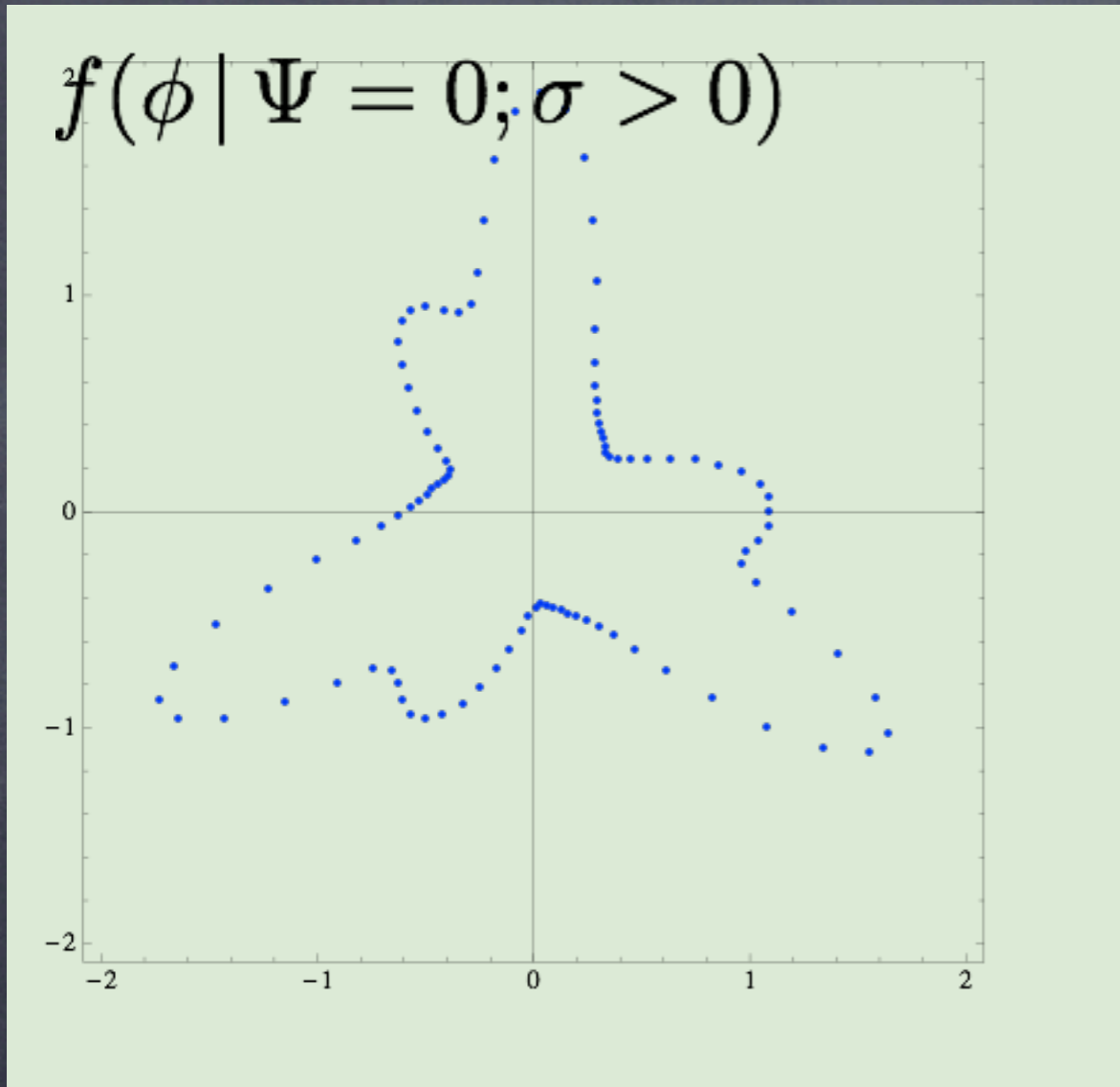
*we propose to study strong interactions
with event chirality sorting.
With transverse initial or inclusive
final SPIN, this would be so
AWESOME*

See our paper for high energy strong parity violation

What do those wave functions look like ?

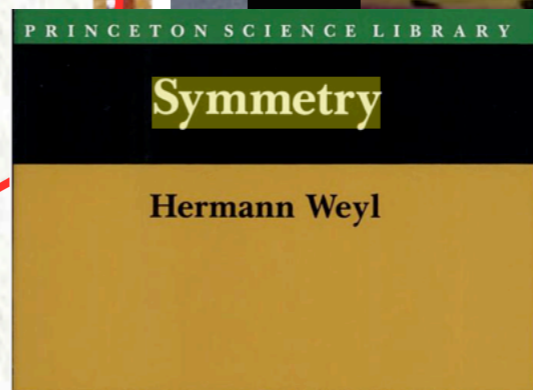
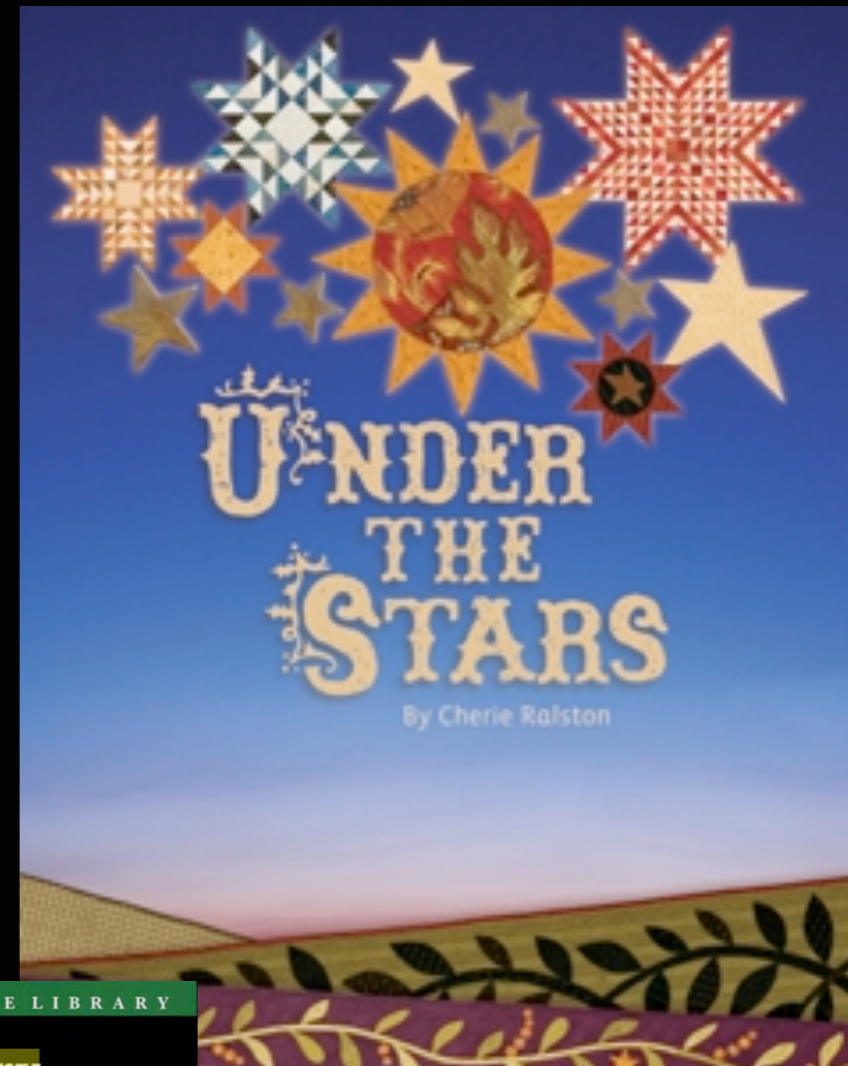


What do those wave functions look like ?



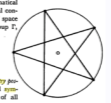
Complex Blocks

 Blazing Star (8+, 8+)	 Barrister's Block	 Corn and Beans	 Broken Dishes (4+, 4+)
 Crown of Thorns (4+, 4+)	 Arizona (4+, 0-)	 Cut Glass Dish	 54-40 or Fight (4+, 4-)
 Dove in the Window	 Dogtooth Violet	 Fool's Puzzle	 Kansas Troubles
 King David's Crown	 Lady of the Lake (1+, 0-+0+)	 Laurel Wreath (4+, 4-)	 Le Moyne Star (4+, 4-)
 Mariner's Compass (4+, 4-)(4+, 4-)(4+, 4-)			



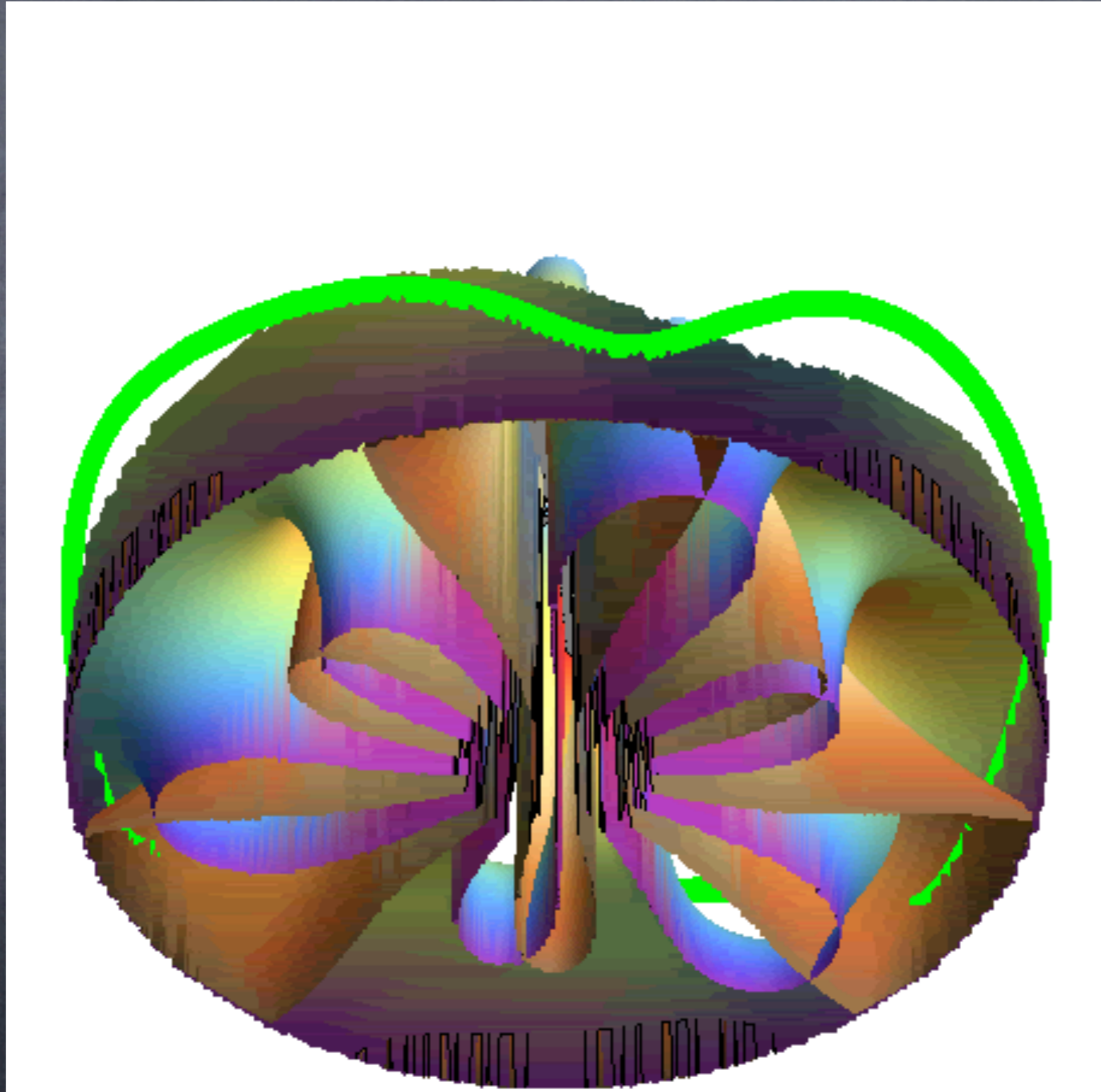
and length in A_4' , in other words the vector $AP' = A_4'$. The translation $T_{AP'}$ results in the translation T_{AP} . What has all this to do with symmetry? It provides the advanced mathematical language to define S_4 . Given a square (Equation 3), three automorphisms of space which leave S_4 unchanged form a group G .

and this group doublets exactly the primary process to S_4 . Space itself has the full symmetry corresponding to the group of all automorphisms of all combinations. The symmetry of any figure in space is described by a subgroup of this group. Take for instance the famous pentagon by which Dr. Face haunts Mathematicopolis the street. It is carried into itself by the five proper rotations around its center O , the angles of which are multiples of $360^\circ/5$ (including the identity), and also by the five reflections in the lines joining O with the five vertices. There are operations (one a group), and this group with us what sort of symmetry the pentagon really has. In other words, a circle has length and dimension. A circle is made of many small segments, although we see different shapes for various and various. Instead of speaking of the rotation R which carries the angle θ into θ' we speak of the vector $\theta = \theta'$, and instead of the group the translation T_{AP} we speak of the vector A' in the end point of the vector A and of the translation T_{AP} in the end point of the vector A' in the end point of the vector A .



D_4 eigenstates (k, k') ; $R_{4k} = +, P_{4k} = -$

...it's time to wind it up



...it's time to wind it up

Happy Birthday, Cary!



...it's time to wind it up



Happy Birthday, Cary!

...it's time to wind it up

Happy Birthday, Cary!





Happy Birthday, Cary!