It's all about GARY

how Physicists
celebrate a birthday

John Ralston

CONTENTS

14) **Exchange Degeneracy in K+ Lambda Or Sigma0 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
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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
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Published in **Annals Phys.98:128,1976**.

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16) **Semilocal Duality in pi0 Photoproduction.**
H.K. Armenian, Gary R. Goldstein, J.P. Rutherfoord, 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
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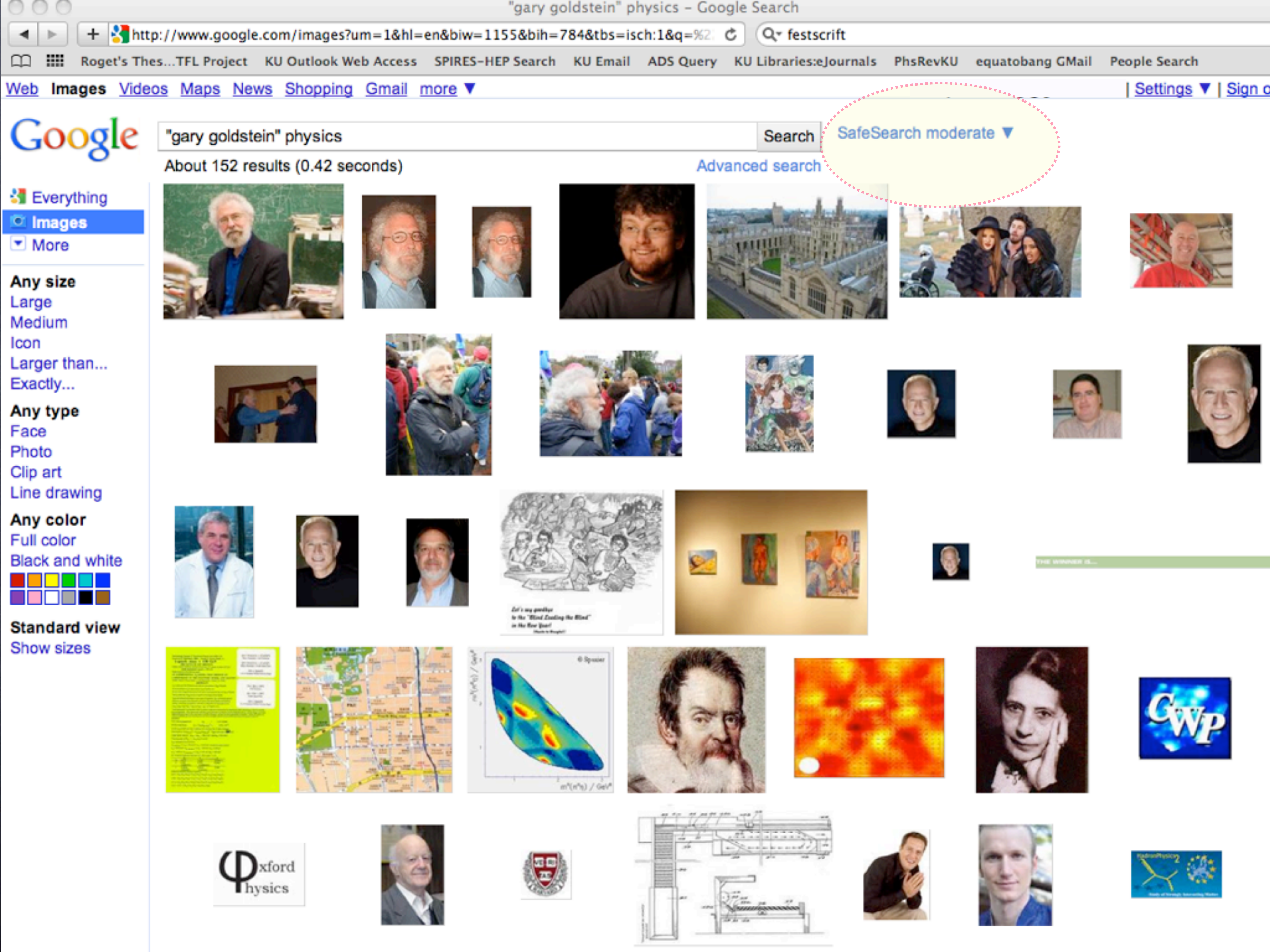
Gary and Mike:

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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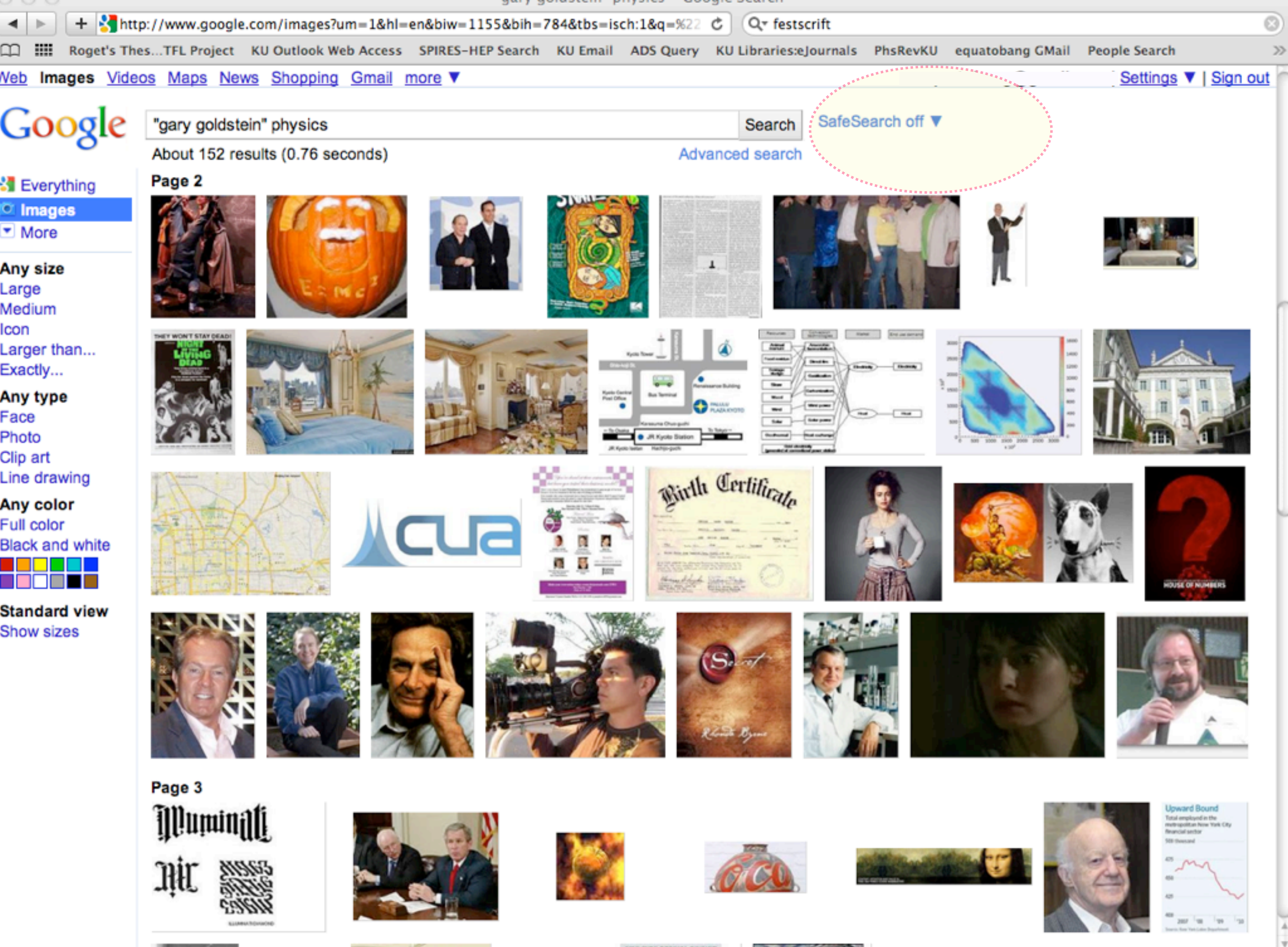
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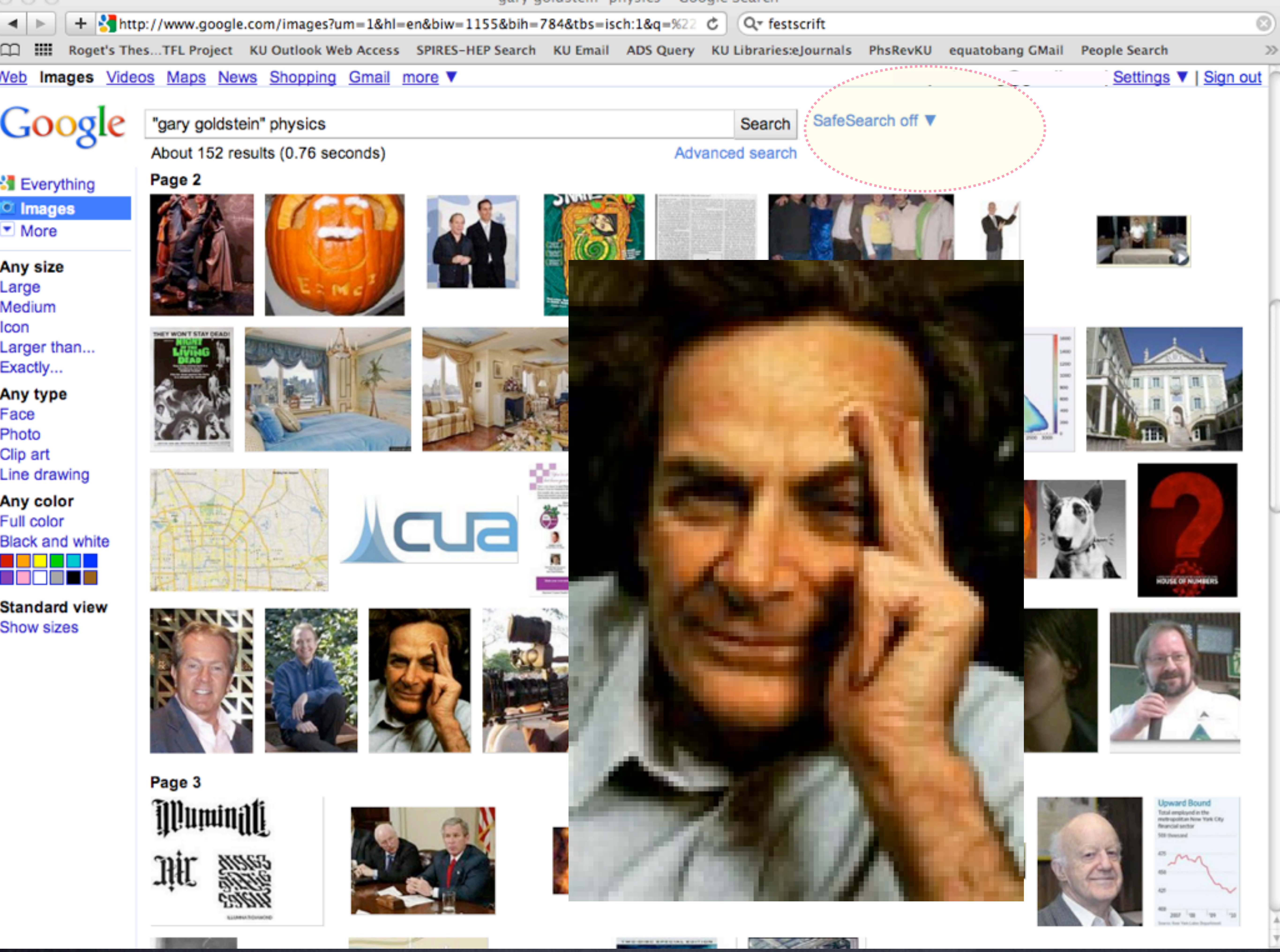
Upward Bound



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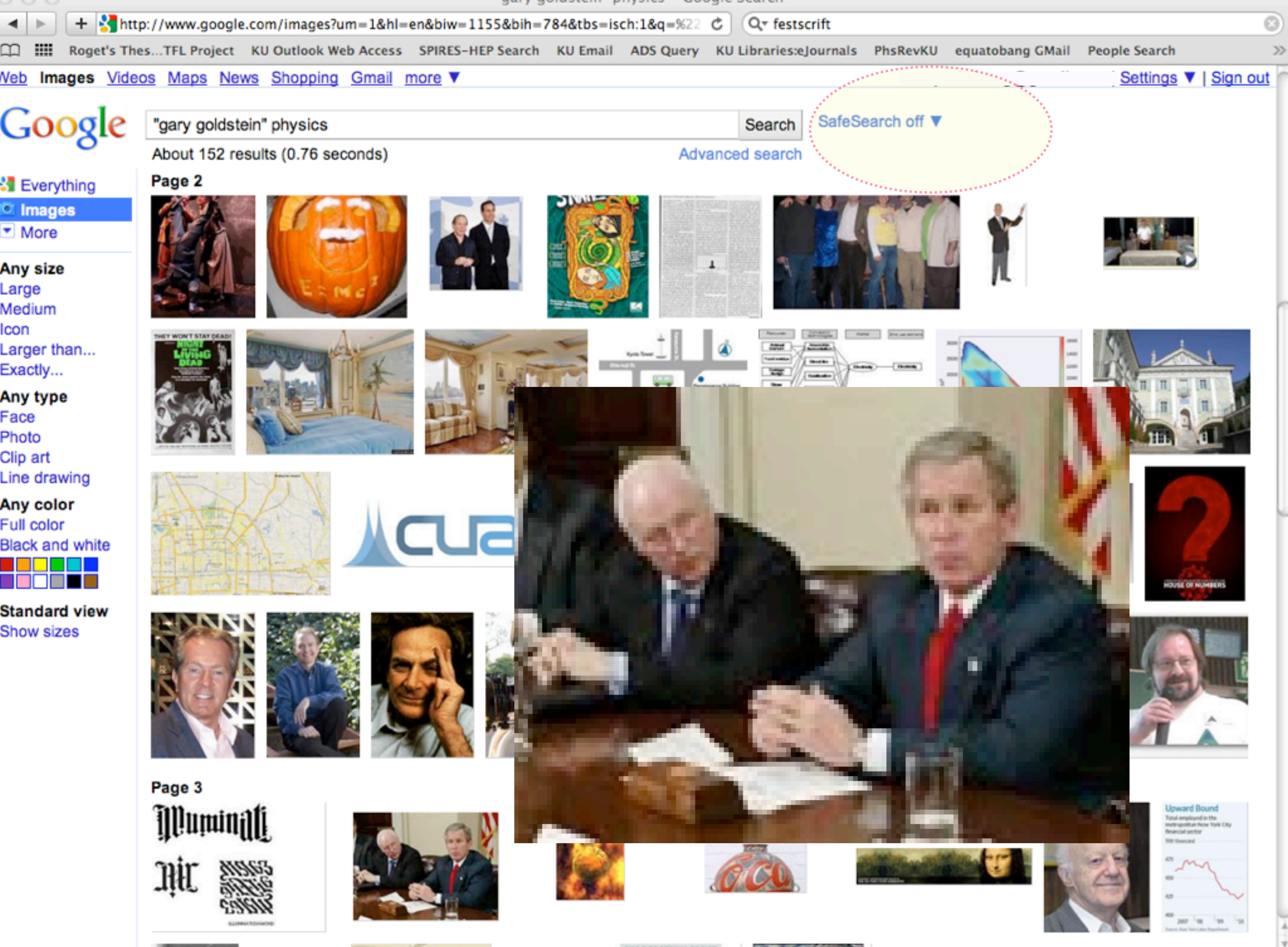

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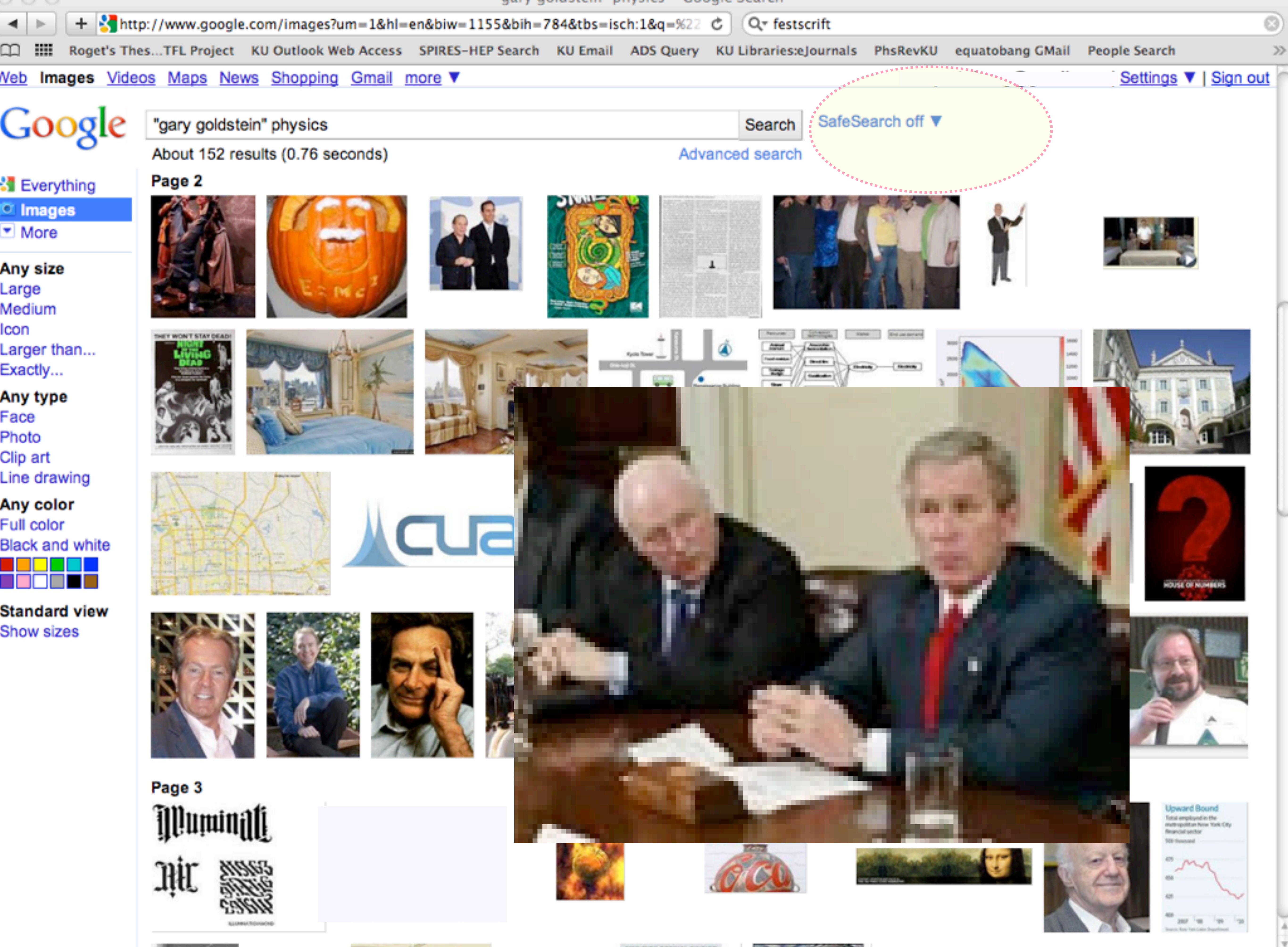

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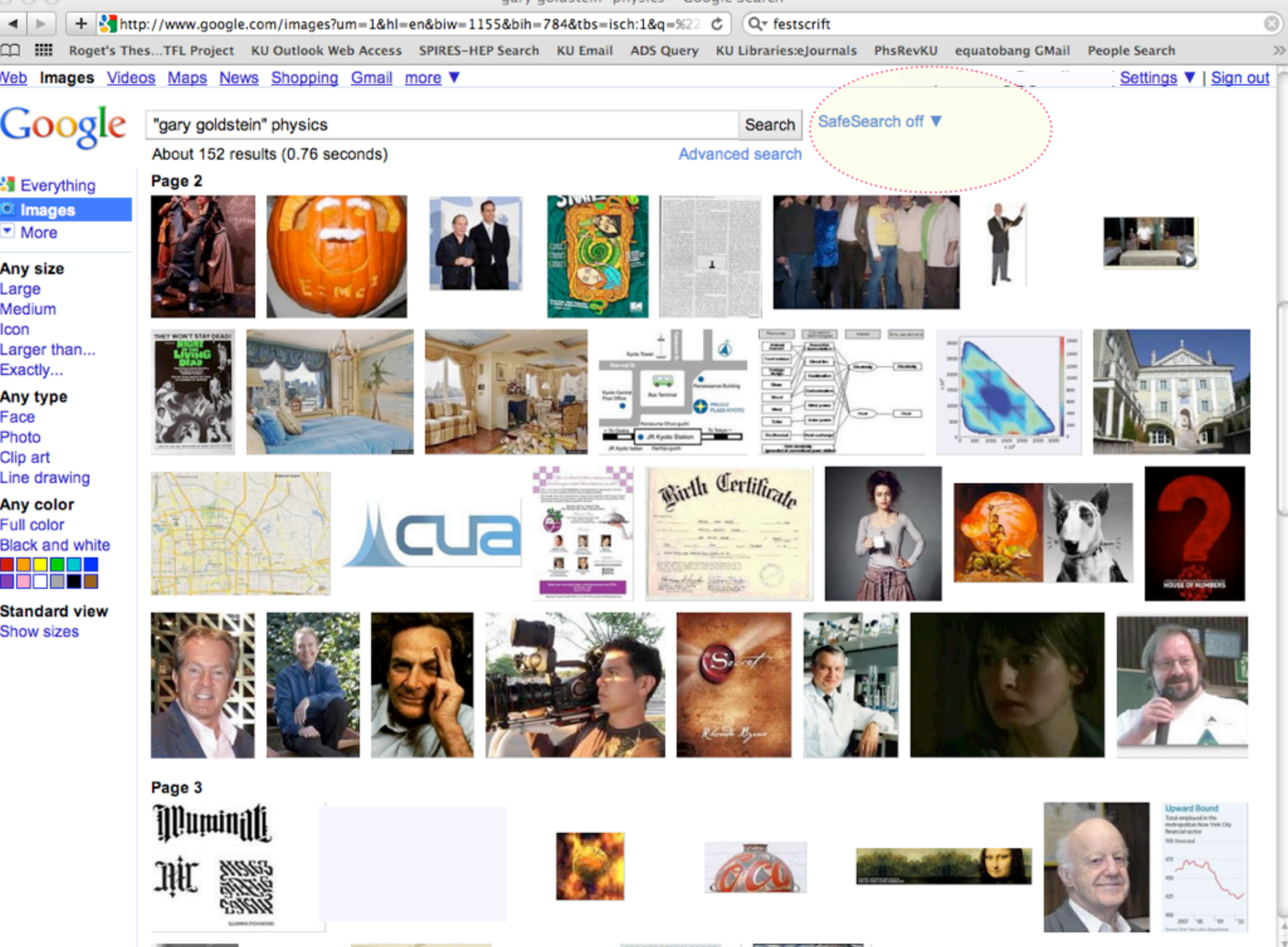

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The Gary Effects:

- 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

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

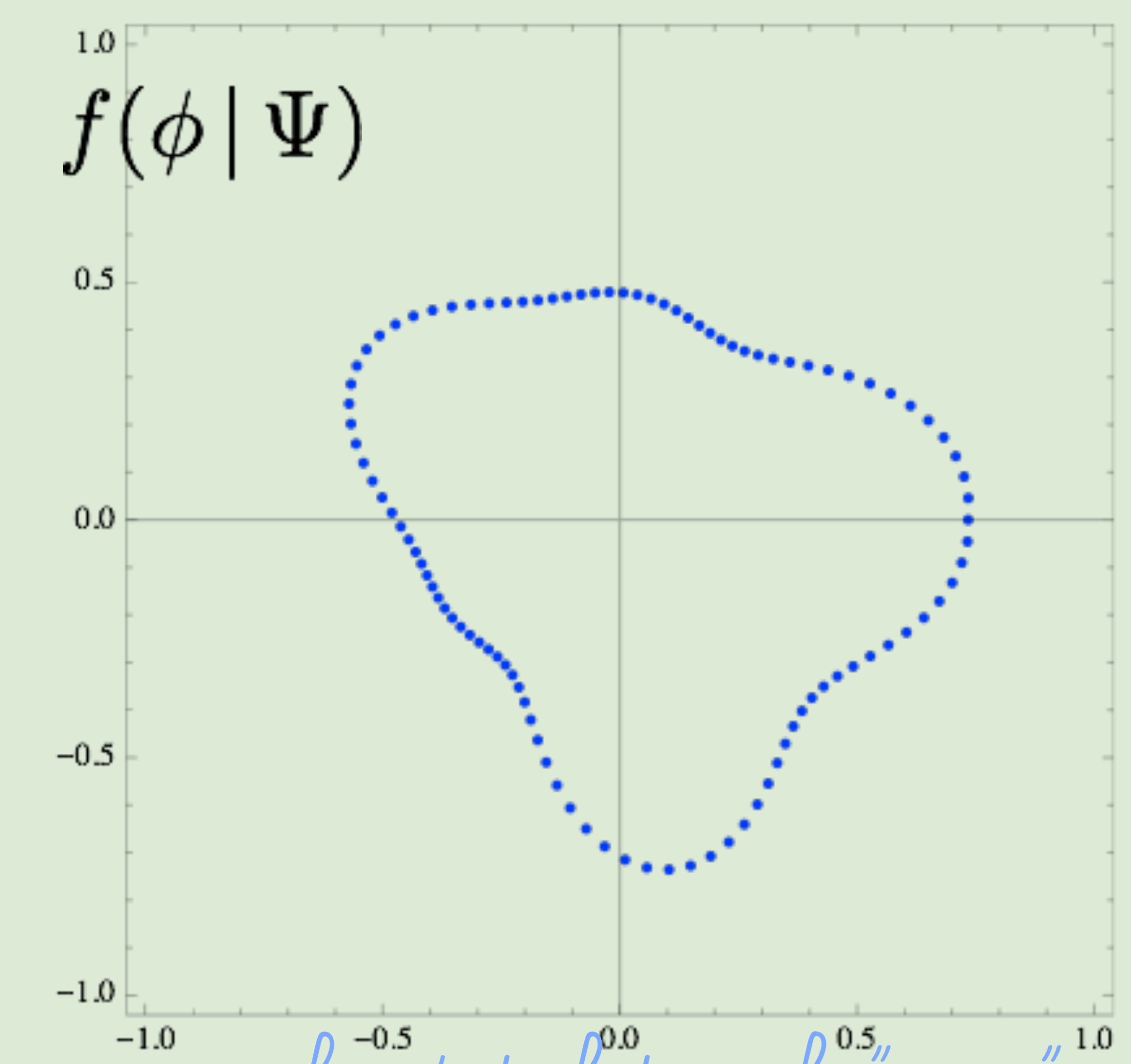
$$f(\phi) = \frac{dN}{d\phi}$$

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

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

for RHIC physics;
Voloshin et al

Every event breaks parity symmetry



angular distribution of..."pions"

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

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

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

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

measures nothing about parity:

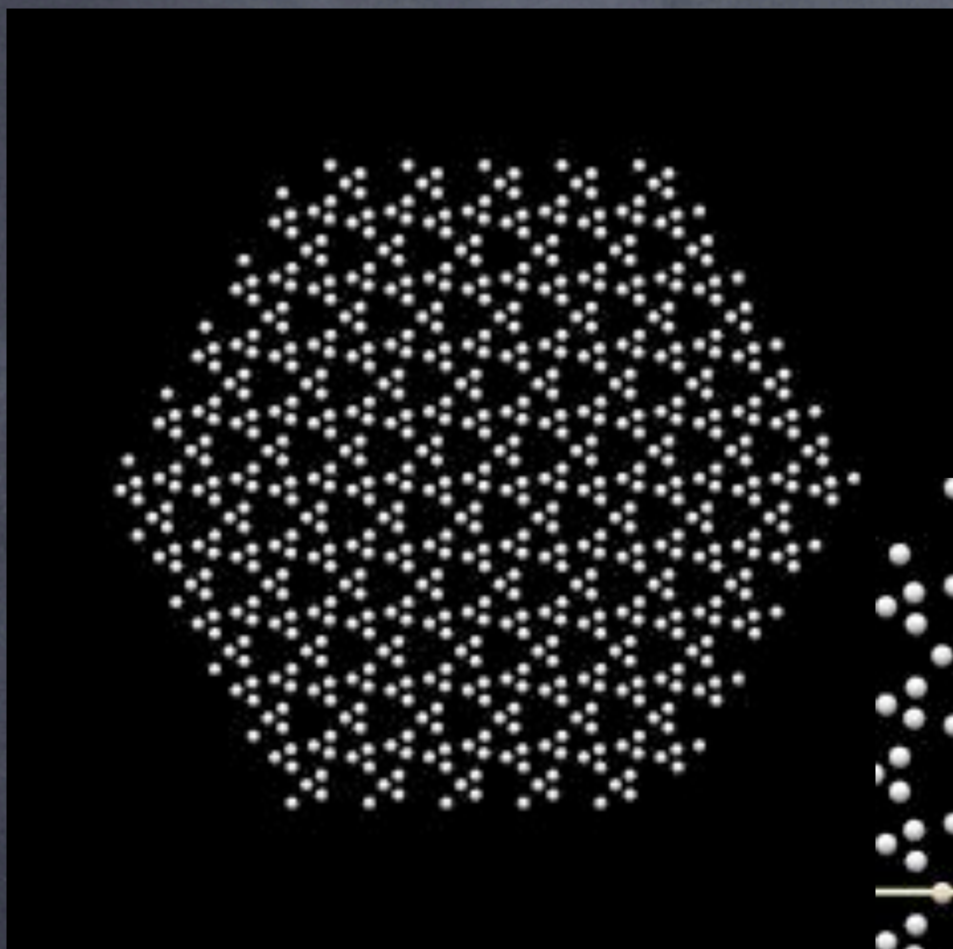
STAR experiment

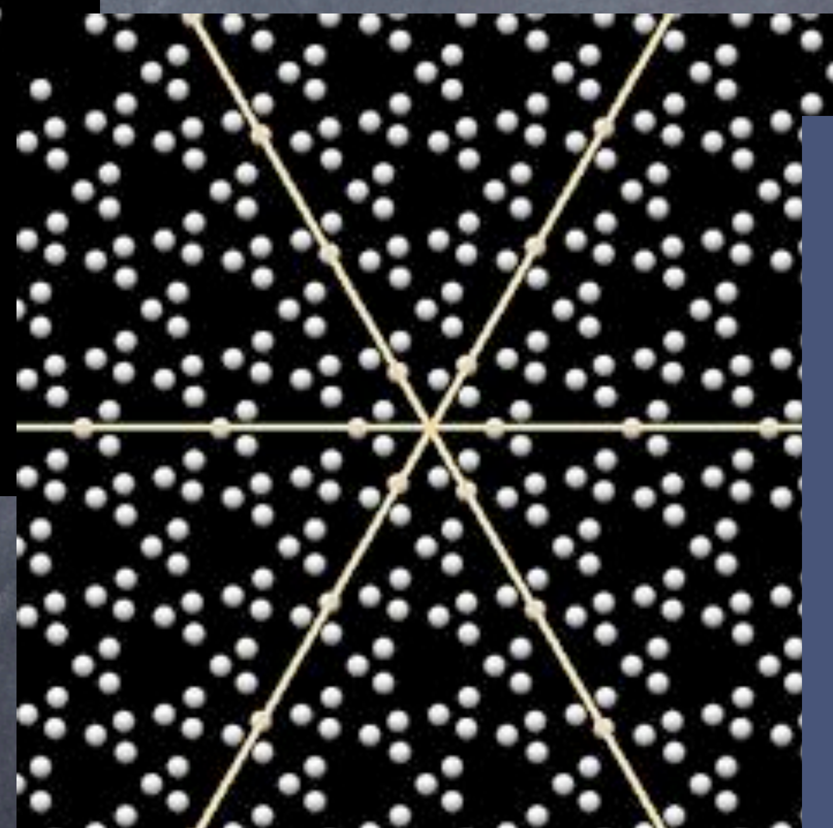
parity and event chirality have been overlooked...

spontaneous parity violation is COMMON in Nature,

even macroscopically

$$f(object\,|\,chirality) \neq 0$$



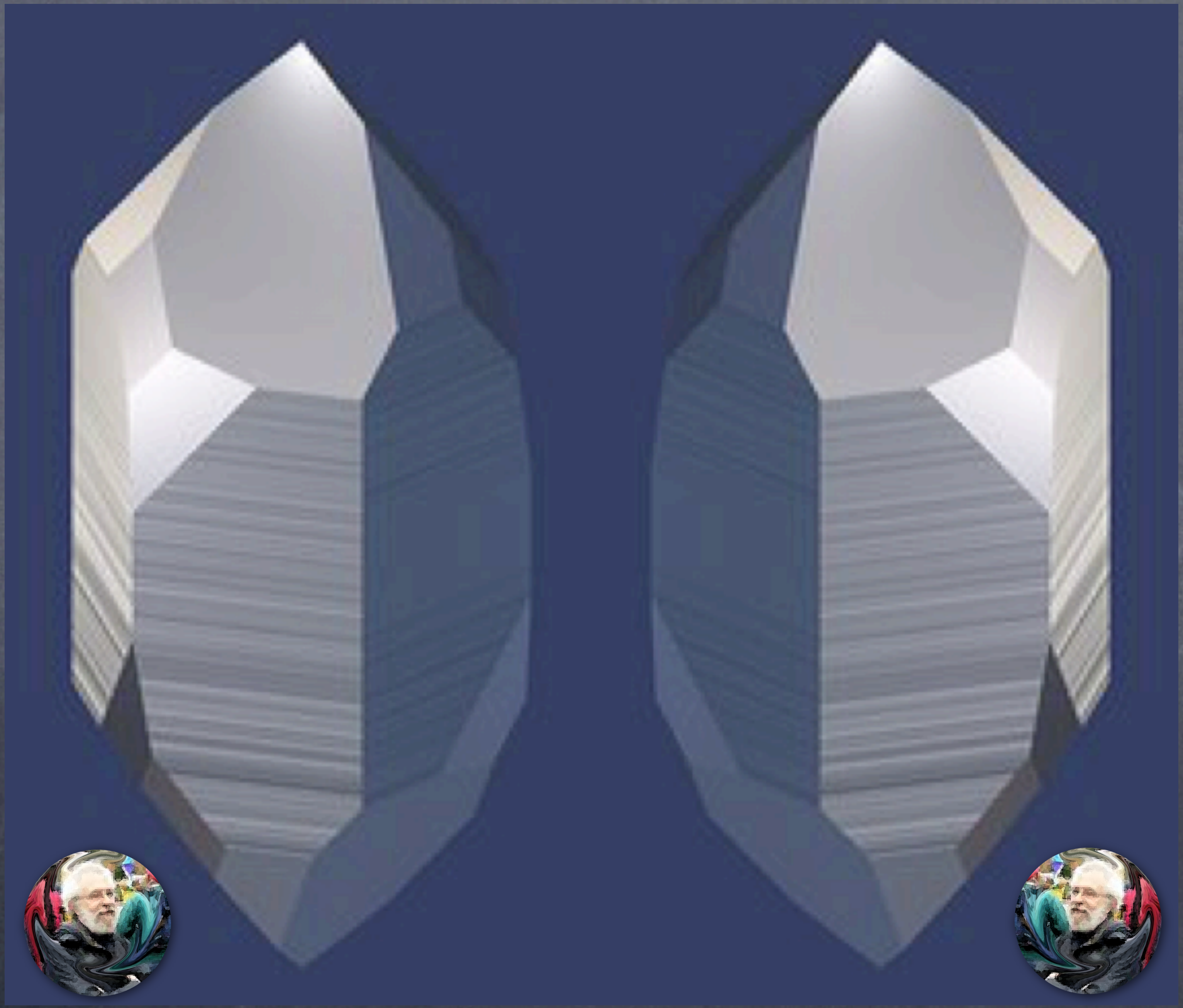


quartz

/www.quartzpage.de

left and right handed quartz, SiO_2

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



sort first;
average
afterwards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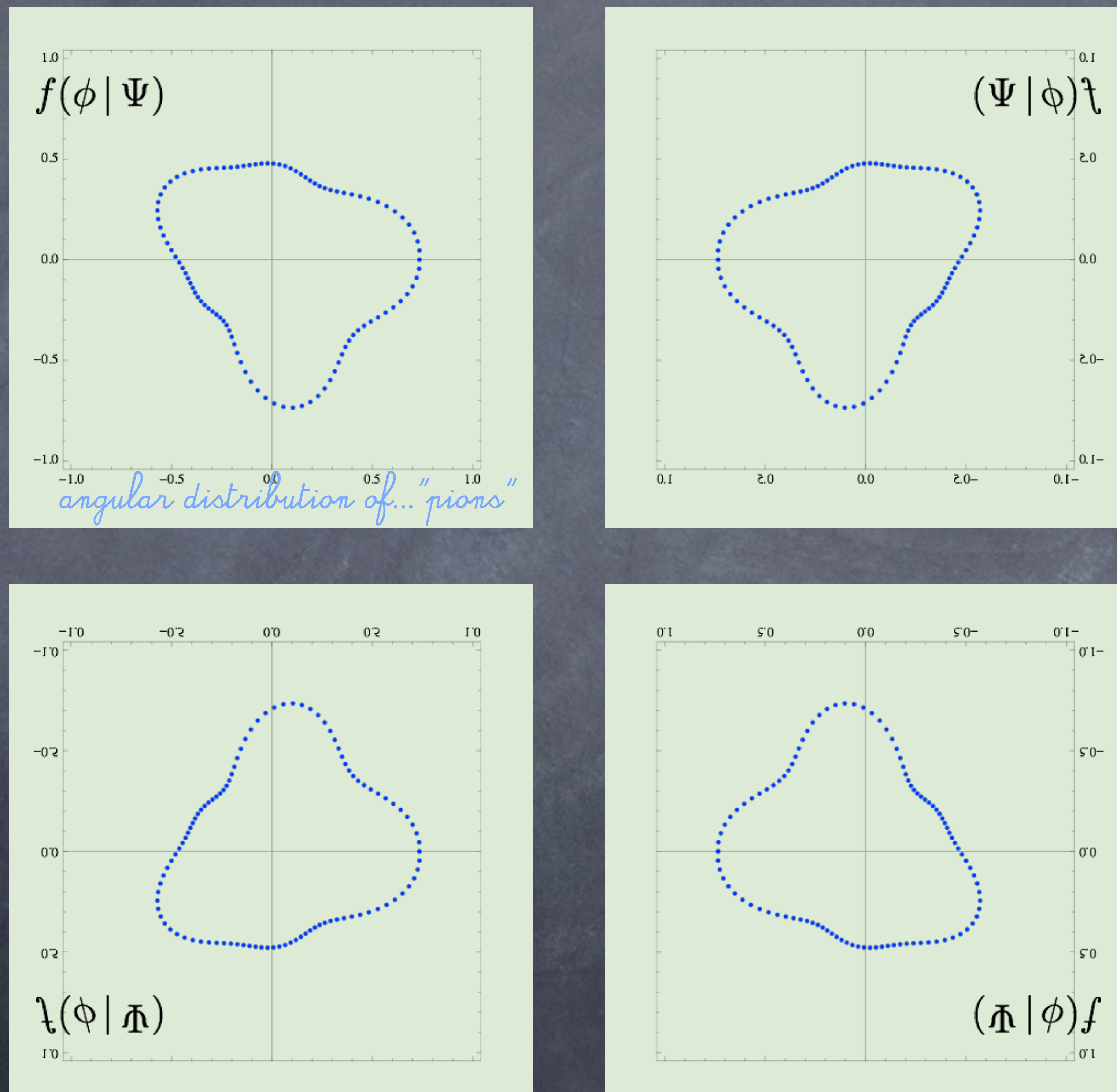
"chirality sorting": four events conditional on orientation



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 $P = -1_{3\times3}$. 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

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

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

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:

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

2N *elements* $(\mathrm{R}_{Nk}, P_{Nk})$, for $k = (0 \ldots N-1)$,

with $\det(\mathrm{R}_{Nk}) = 1$, $det(P_{Nk}) = -1$

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...N-1

$$P_{Nk} = \begin{pmatrix} cos2\pi k/N & sin2\pi k/N \\ sin2\pi k/N & -cos2\pi k/N \end{pmatrix};$$

$$R_{Nk} = \begin{pmatrix} cos2\pi k/N & -sin2\pi k/N \\ sin2\pi k/N & cos2\pi k/N \end{pmatrix}.$$

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

the whirlyness of the classical distribution...

$$\int_0^{2\pi} d\phi \;\; f(-i\frac{\partial}{\partial\phi})f$$

...equals zero.

In quantum mechanics...

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

2D rotationally invariant; D_N (even, odd)

to get ψ from f ... analytically continue

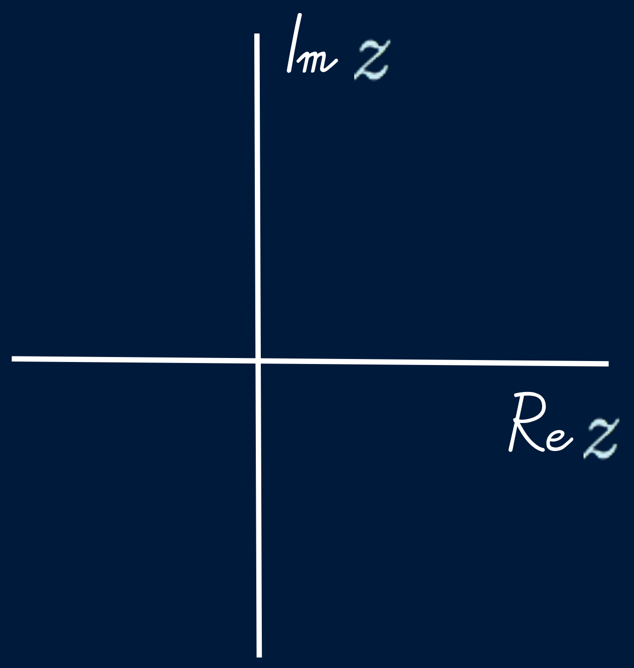
Analytic continuation: $z = e^{i\phi}$

$$f(\phi) = \sum_{m=-\ell}^{\ell} f_m e^{im\phi} = z^{-\ell} \sum_{m=0}^{2\ell} f_m z^m,$$

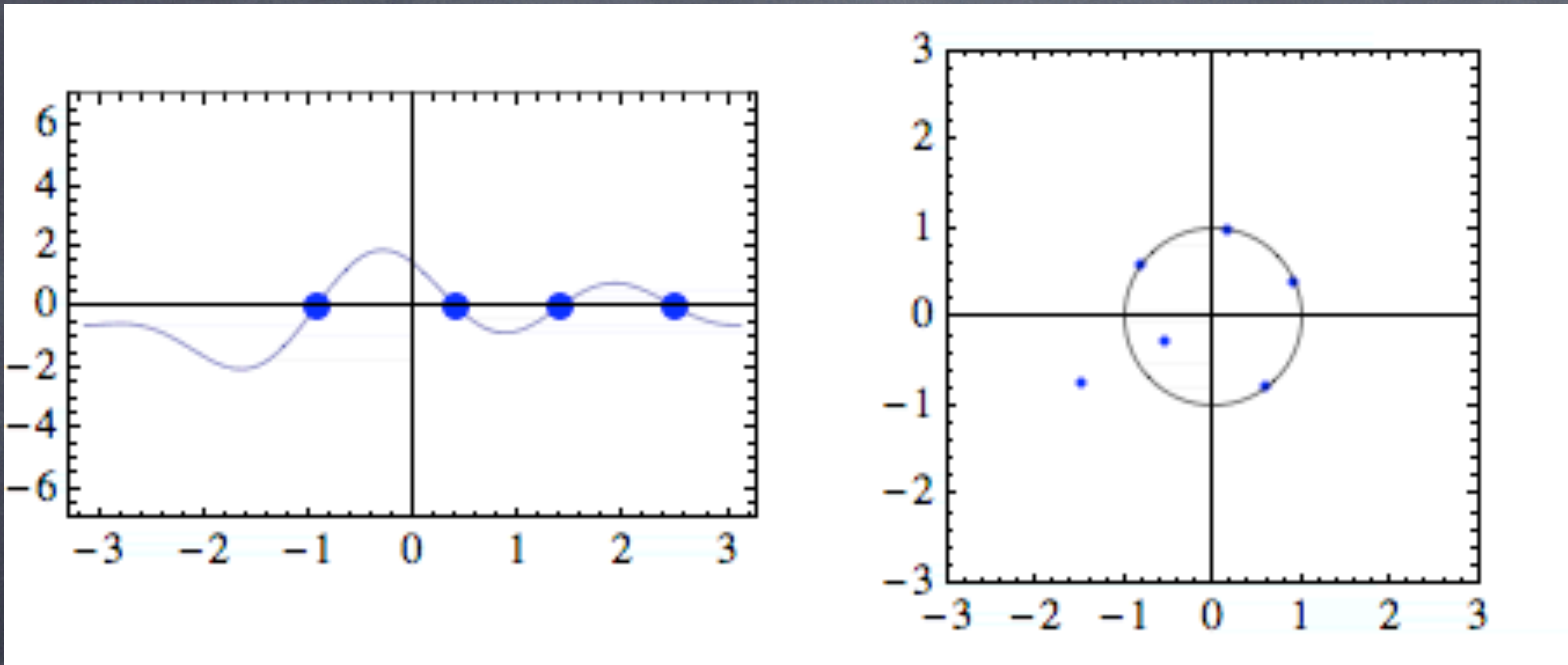
$$= f_0 z^{-\ell} \prod_{k=1}^{2\ell} (z - z_k).$$

"fundamental theorem of algebra"

poles and zeroes



under rotations, complex zeros transform like 2-vectors



under rotations, complex zeros transform like 2-vectors

Continuation, continued:

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

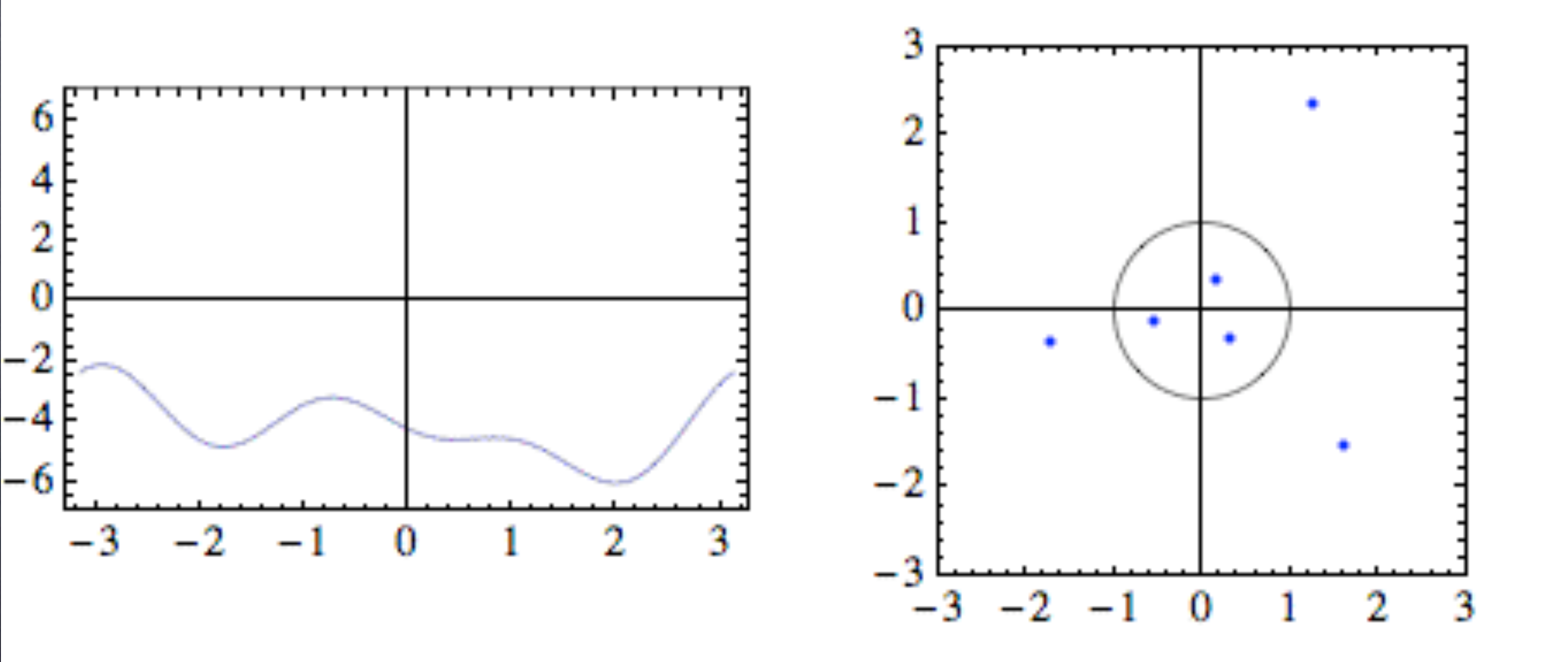
$$f(\phi) = real \rightarrow zeroes\, in\, pairs\, (z_k,\, 1/z_k^*)$$

$$f(z;\, |z| = 1) \quad = \quad \psi(z)^* \psi(z)$$
$$where \quad \psi(z) \quad = \quad \psi_0 \prod_{k}^{\ell} \frac{z - z_k}{z}$$

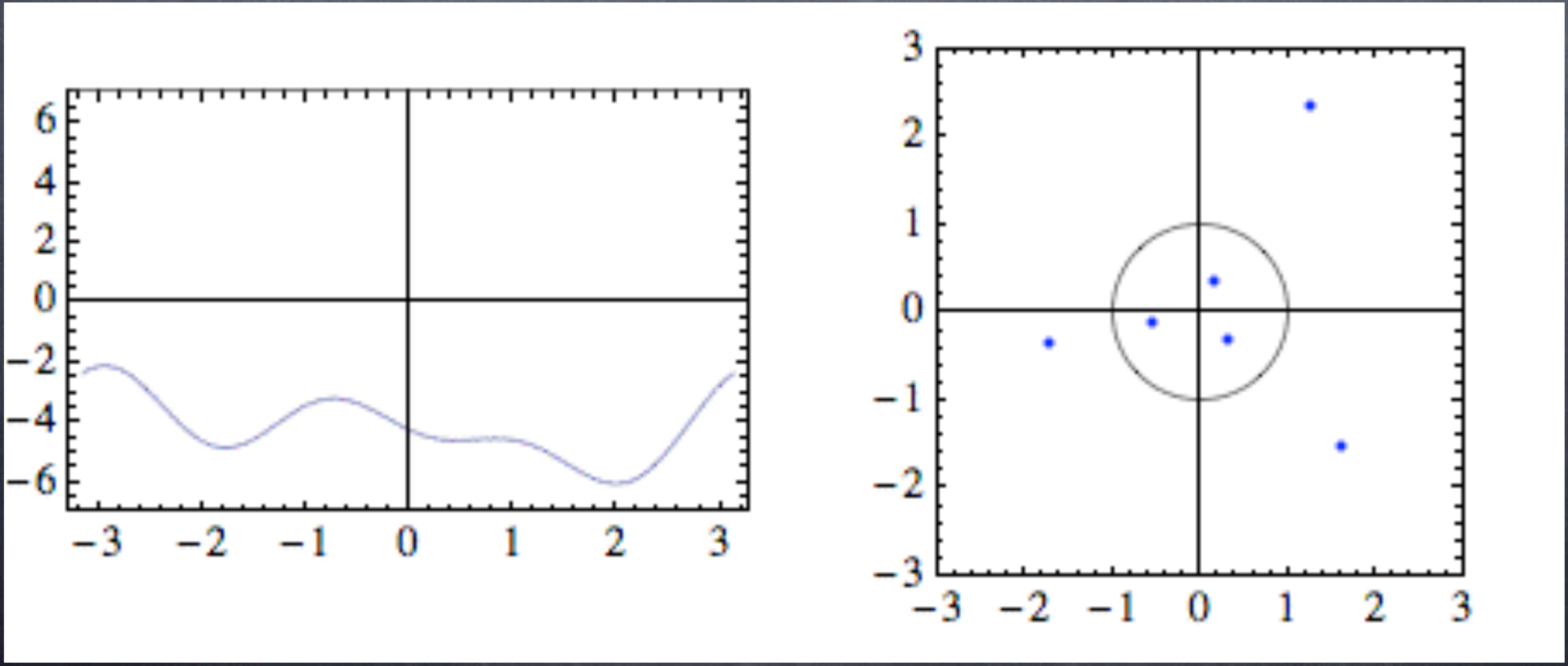
note, with symmetric singularities at zero

adding a constant:

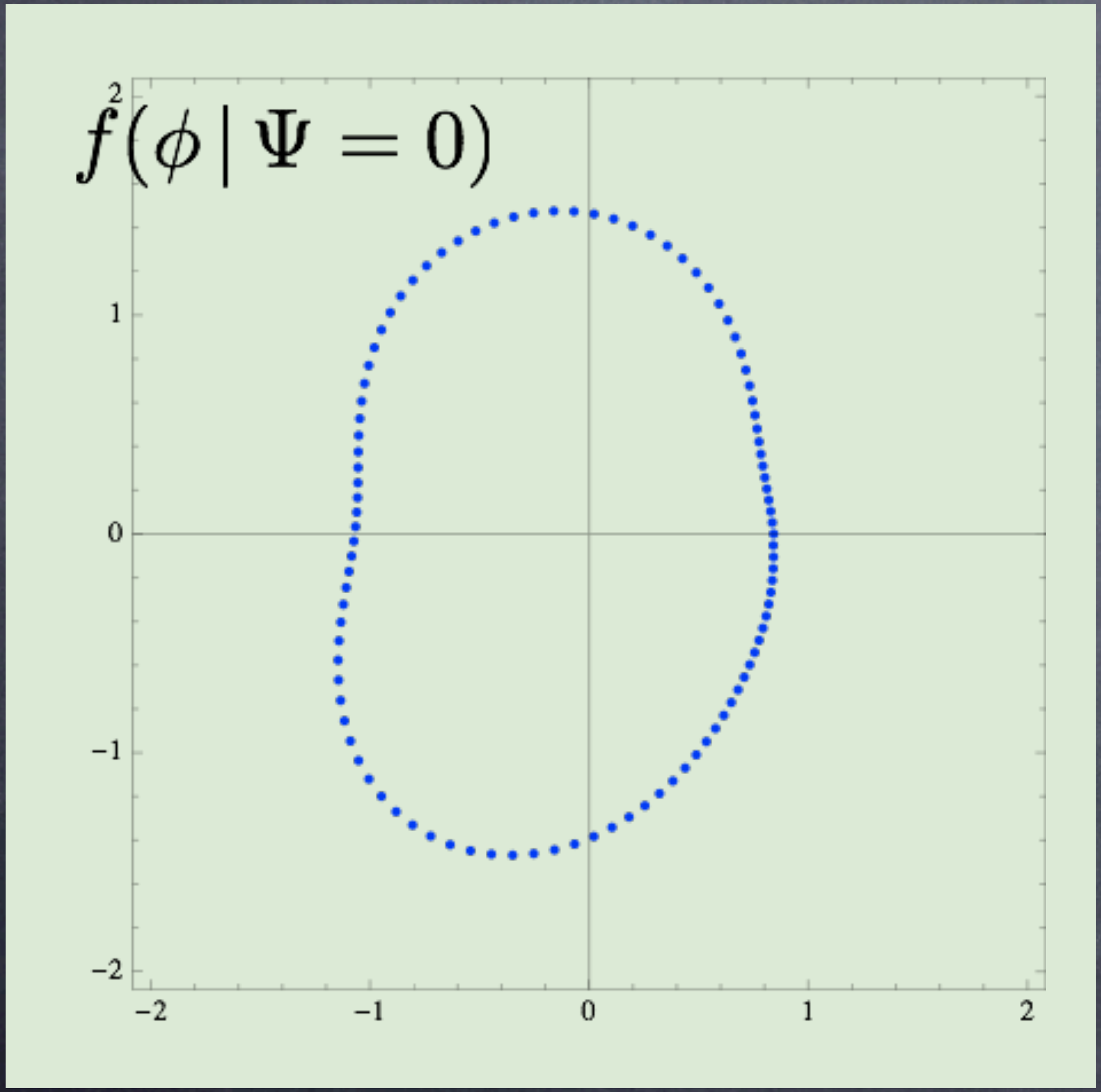
adding a constant:

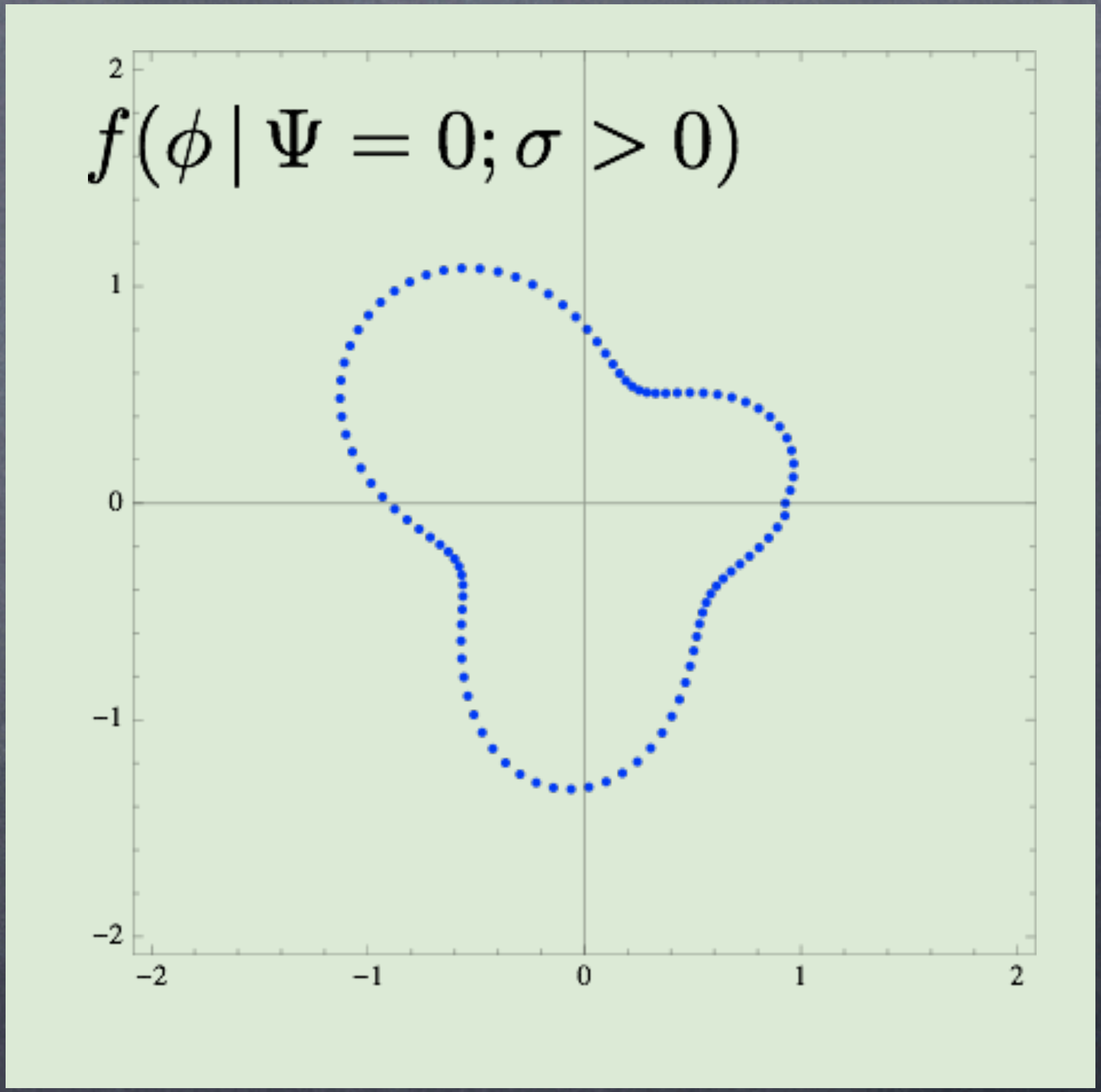


adding a constant:



a test run, cutting on handicity

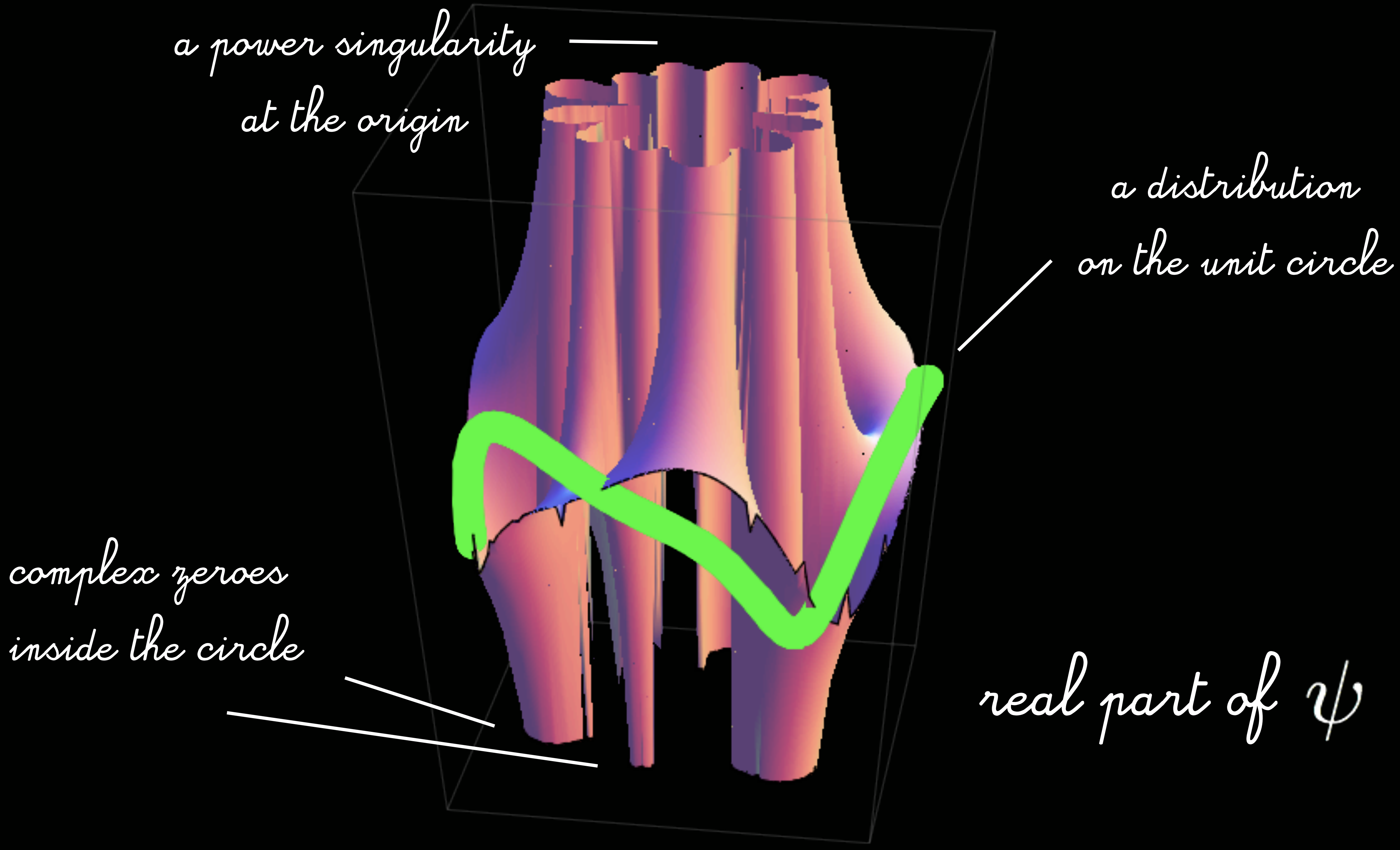




we propose to study strong interactions
with event chirality sorting.
With transverse initial or inclusive
final SPIN, this would be so
AWESOME

See our paper for high energy strong parity violation

What do those wave functions look like ?



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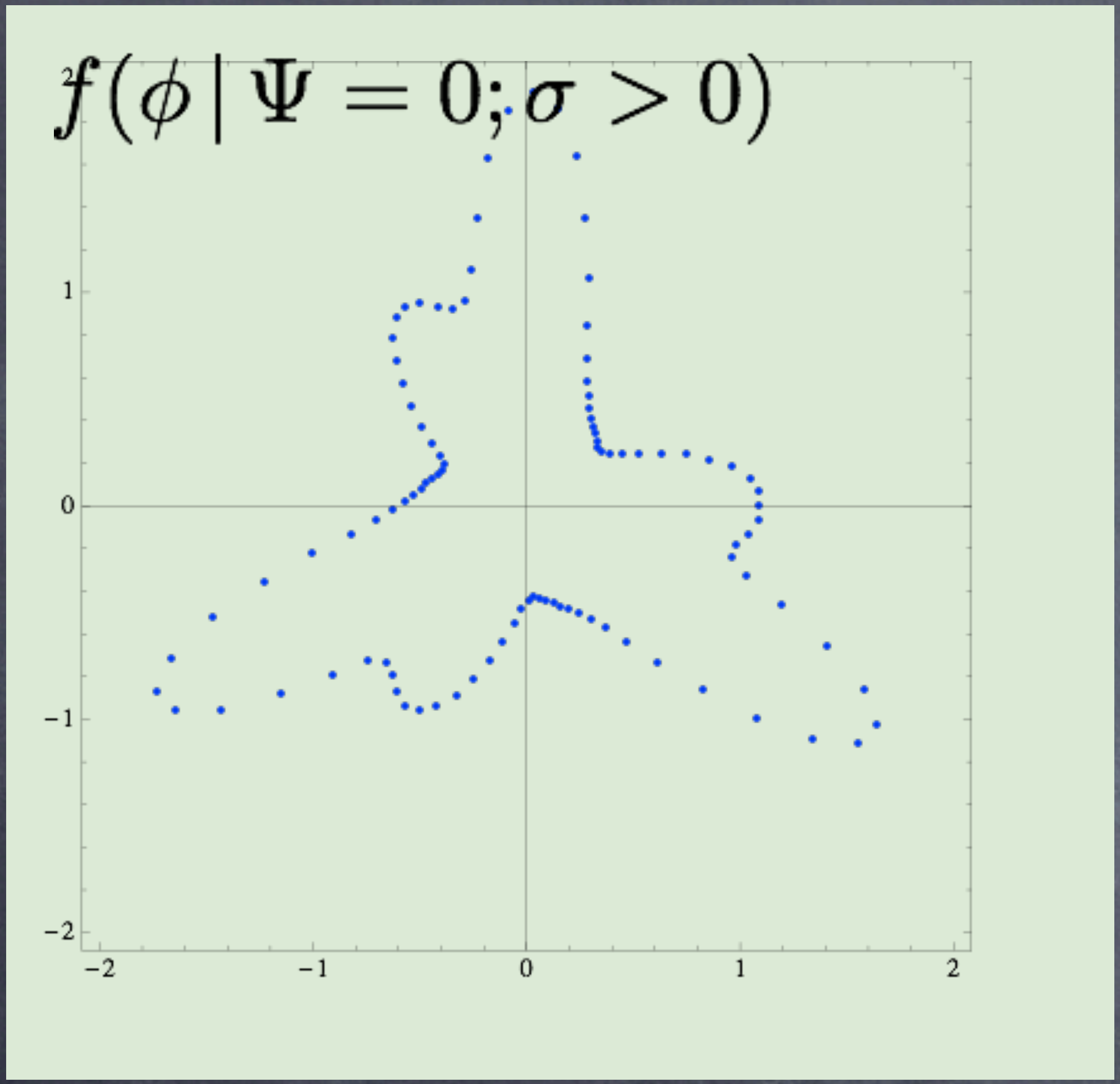
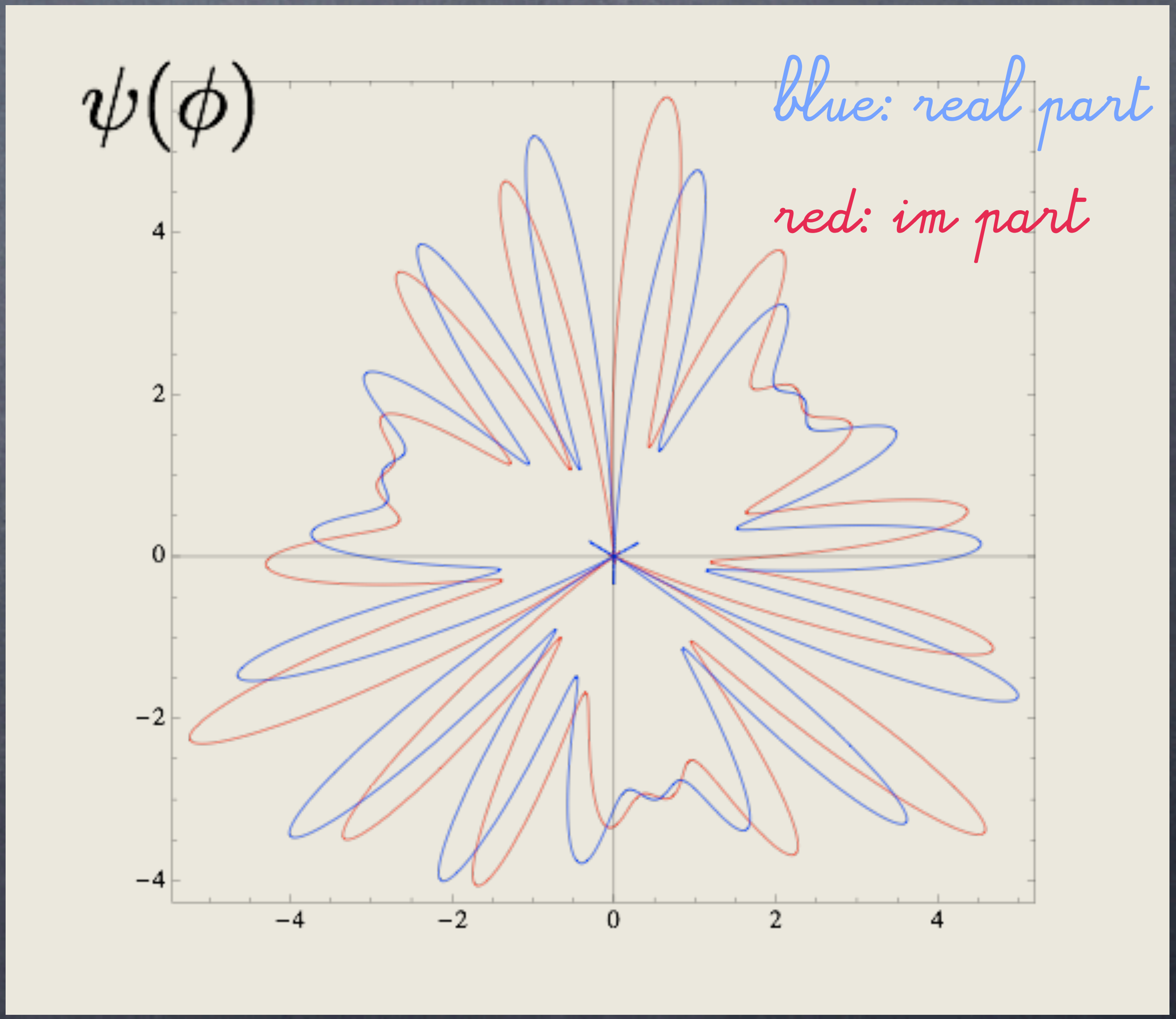
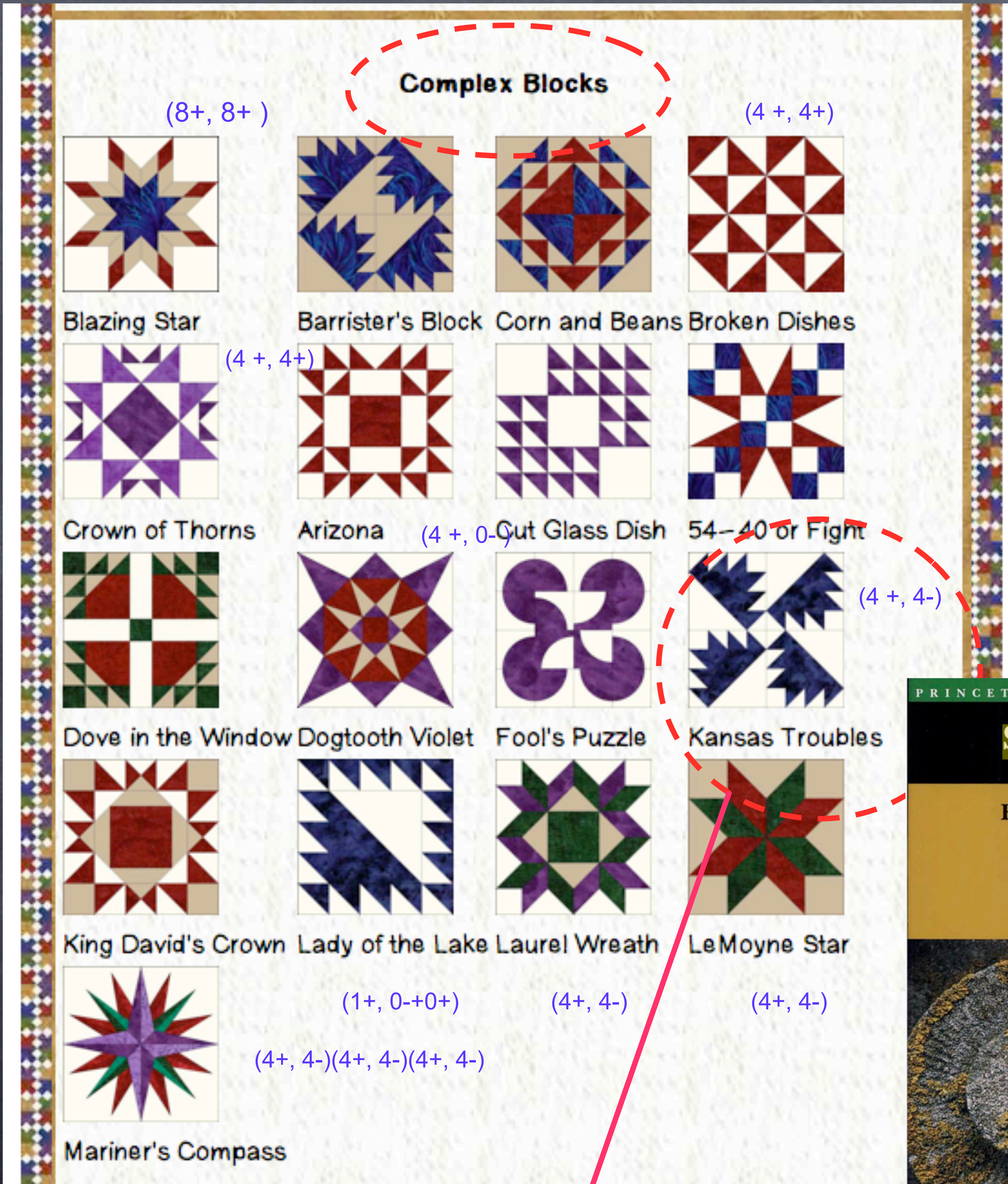
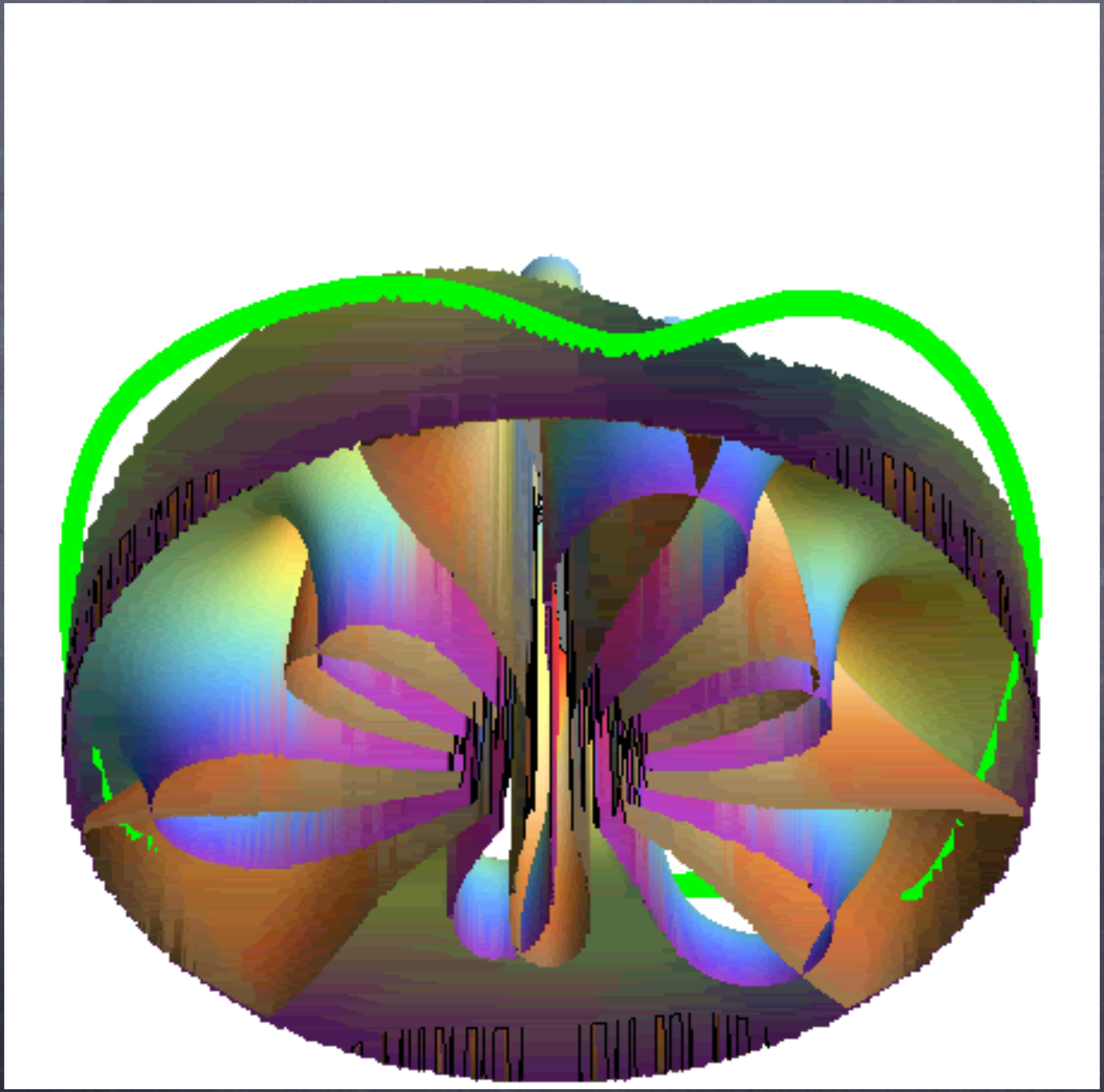






D_4 eigenstates (k, k'); $R_4 k = +$, $P_4 k = -$

...it's time to wind it up



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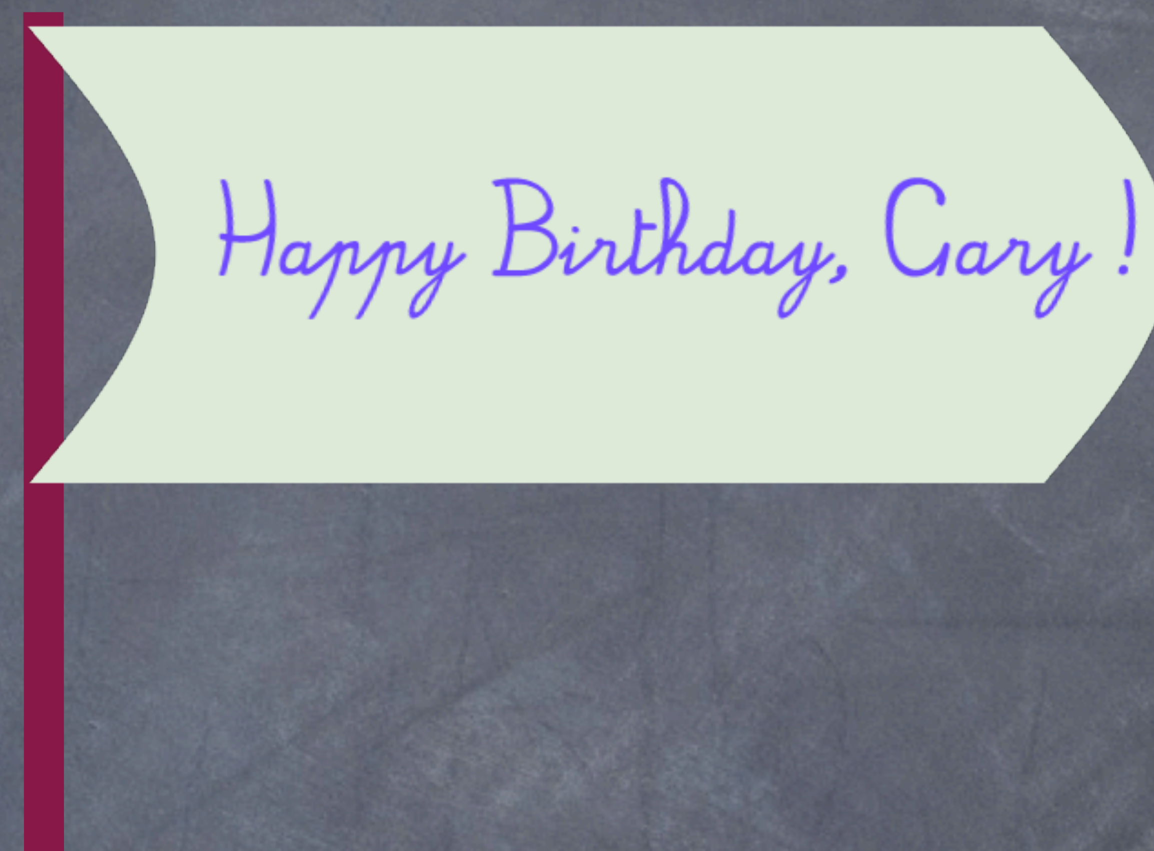

...it's time to wind it up

Happy Birthday, Gary !