(How) could AI (help to) find deeper physics?

Many **TOE claims** – ignored by mainstream, now **AI can rigorously test**

Why needed? 1) **Problems** e.g. unify with gravity, derive "beyond SM", etc.
2) **complexity**: gigantic guess&fit "epicycles", **parameters**: ~**30** → a few
3) **particles** are **field configurations**, not **points – perturbative approx.**
finish "shut up and calculate" understanding impossibility ~creationism

Early: LLM vibe physics word salads, "find TOE and show its greatness"

Now: **autonomous environments** with **rigorous top AI-agents** writing and running **simulations** to **test** various **physics agreements**, like github/**OpenWave** (Fable): 21 **criterions** e.g. **charge quantization**

Status	Liquid Crystal (M5)	HydroBoros (M7)	EWT (M4)	Ouroboros (M6)	MIT (M8)
✅ validated in-platform	9	0	0	3	0
⚠️ partial / with caveats	7	8	8	3	1
❌ honest negative	0	0	3	3	0
🔶 in progress	0	0	0	0	0
🚧 planned / not yet	5	13	10	12	20
Total criteria	**21**	**21**	**21**	**21**	**21**

Currently the most promising – let's look

en.wikipedia.org/wiki/**Marc_Fleury**

en.wikipedia.org/wiki/**Paul_Werbos**

open for more...

Why do we need **deeper physics?**

1) E.g. **SM incompatible with GR …**
   EMC: quarks in **nuclei** don't work

2) **General form able to guess&fit all**

Derive like Copernican Revolution?

e.g. **M5**: $\mathcal{L} = -F_{\mu\nu\alpha\beta}F^{\mu\nu\alpha\beta} - V_{\mathrm{H}}(M)$

quantized charge: $F_{\mu\nu\alpha\beta} = [\partial_\mu M, \partial_\nu M]_{\alpha\beta}$

unifies EM+QM+GEM +particle menagerie

from ~3 parameters derive ~30 of SM

3) **Particles are fields not points**
   e.g. electron: $E \sim 1/r^2$, dipole,
   angular momentum – of field

epicycles…?

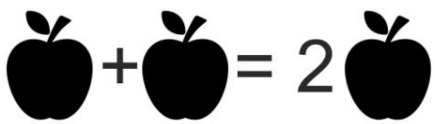
1
$$-\tfrac{1}{2}\partial_\nu g^a_\mu \partial_\nu g^a_\mu - g_s f^{abc}\partial_\mu g^a_\nu g^b_\mu g^c_\nu - \tfrac{1}{4}g_s^2 f^{abc}f^{ade}g^b_\mu g^c_\nu g^d_\mu g^e_\nu + \tfrac{1}{2}ig_s^2(\bar{q}^\sigma_i\gamma^\mu q^\sigma_j)g^a_\mu + \bar{G}^a\partial^2 G^a + g_s f^{abc}\partial_\mu \bar{G}^a G^b g^c_\mu$$

2
$$- \partial_\nu W^+_\mu \partial_\nu W^-_\mu - M^2 W^+_\mu W^-_\mu - \tfrac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \tfrac{1}{2c_w^2}M^2 Z^0_\mu Z^0_\mu - \tfrac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - \tfrac{1}{2}\partial_\mu H \partial_\mu H - \tfrac{1}{2}m_h^2 H^2 - \partial_\mu\phi^+\partial_\mu\phi^- - M^2\phi^+\phi^- - \tfrac{1}{2}\partial_\mu\phi^0\partial_\mu\phi^0 - \tfrac{1}{2c_w^2}M\phi^0\phi^0 - \beta_h[\tfrac{2M^2}{g^2} + \tfrac{2M}{g}H + \tfrac{1}{2}(H^2 + \phi^0\phi^0 + 2\phi^+\phi^-)] + \tfrac{2M^4}{g^2}\alpha_h - igc_w[\partial_\nu Z^0_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - Z^0_\nu(W^+_\mu\partial_\nu W^-_\mu - W^-_\mu\partial_\nu W^+_\mu) + Z^0_\mu(W^+_\nu\partial_\nu W^-_\mu - W^-_\nu\partial_\nu W^+_\mu)] - igs_w[\partial_\nu A_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - A_\nu(W^+_\mu\partial_\nu W^-_\mu - W^-_\mu\partial_\nu W^+_\mu) + A_\mu(W^+_\nu\partial_\nu W^-_\mu - W^-_\nu\partial_\nu W^+_\mu)] - \tfrac{1}{2}g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu + \tfrac{1}{2}g^2 W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2c_w^2(Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) + g^2s_w^2(A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2s_wc_w[A_\mu Z^0_\nu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - 2A_\mu Z^0_\mu W^+_\nu W^-_\nu] - g\alpha[H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-] - \tfrac{1}{8}g^2\alpha_h[H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + 4H^2\phi^+\phi^- + 2(\phi^0)^2H^2] - gMW^+_\mu W^-_\mu H - \tfrac{1}{2}g\tfrac{M}{c_w^2}Z^0_\mu Z^0_\mu H - \tfrac{1}{2}ig[W^+_\mu(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0) - W^-_\mu(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)] + \tfrac{1}{2}g[W^+_\mu(H\partial_\mu\phi^- - \phi^-\partial_\mu H) - W^-_\mu(H\partial_\mu\phi^+ - \phi^+\partial_\mu H)] + \tfrac{1}{2}g\tfrac{1}{c_w}(Z^0_\mu(H\partial_\mu\phi^0 - \phi^0\partial_\mu H) - ig\tfrac{s_w^2}{c_w}MZ^0_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) + igs_wMA_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) - ig\tfrac{1-2c_w^2}{2c_w}Z^0_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) + igs_wA_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) - \tfrac{1}{4}g^2W^+_\mu W^-_\mu[H^2 + (\phi^0)^2 + 2\phi^+\phi^-] - \tfrac{1}{4}g^2\tfrac{1}{c_w^2}Z^0_\mu Z^0_\mu[H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2\phi^+\phi^-] - \tfrac{1}{2}g^2\tfrac{s_w^2}{c_w}Z^0_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) - \tfrac{1}{2}ig^2\tfrac{s_w^2}{c_w}Z^0_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) + \tfrac{1}{2}g^2s_wA_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) + \tfrac{1}{2}ig^2s_wA_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) - g^2\tfrac{s_w}{c_w}(2c_w^2 - 1)Z^0_\mu A_\mu\phi^+\phi^- - g^1s_w^2A_\mu A_\mu\phi^+\phi^-$$

3
$$- \bar{e}^\lambda(\gamma\partial + m_e^\lambda)e^\lambda - \bar{\nu}^\lambda\gamma\partial\nu^\lambda - \bar{u}^\lambda_j(\gamma\partial + m_u^\lambda)u^\lambda_j - \bar{d}^\lambda_j(\gamma\partial + m_d^\lambda)d^\lambda_j + igs_wA_\mu[-(\bar{e}^\lambda\gamma^\mu e^\lambda) + \tfrac{2}{3}(\bar{u}^\lambda_j\gamma^\mu u^\lambda_j) - \tfrac{1}{3}(\bar{d}^\lambda_j\gamma^\mu d^\lambda_j)] + \tfrac{ig}{4c_w}Z^0_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{e}^\lambda\gamma^\mu(4s_w^2 - 1 - \gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(\tfrac{4}{3}s_w^2 - 1 - \gamma^5)u^\lambda_j) + (\bar{d}^\lambda_j\gamma^\mu(1 - \tfrac{8}{3}s_w^2 - \gamma^5)d^\lambda_j)] + \tfrac{ig}{2\sqrt{2}}W^+_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(1+\gamma^5)C_{\lambda\kappa}d^\kappa_j)] + \tfrac{ig}{2\sqrt{2}}W^-_\mu[(\bar{e}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{d}^\kappa_jC^\dagger_{\lambda\kappa}\gamma^\mu(1+\gamma^5)u^\lambda_j)]$$

4
$$+ \tfrac{ig}{2\sqrt{2}}\tfrac{m_e^\lambda}{M}[-\phi^+(\bar{\nu}^\lambda(1-\gamma^5)e^\lambda) + \phi^-(\bar{e}^\lambda(1+\gamma^5)\nu^\lambda)] - \tfrac{g}{2}\tfrac{m_e^\lambda}{M}[H(\bar{e}^\lambda e^\lambda) + i\phi^0(\bar{e}^\lambda\gamma^5e^\lambda)] + \tfrac{ig}{2M\sqrt{2}}\phi^+[-m_d^\kappa(\bar{u}^\lambda_jC_{\lambda\kappa}(1-\gamma^5)d^\kappa_j) + m_u^\lambda(\bar{u}^\lambda_jC_{\lambda\kappa}(1+\gamma^5)d^\kappa_j] + \tfrac{ig}{2M\sqrt{2}}\phi^-[m_d^\lambda(\bar{d}^\lambda_jC^\dagger_{\lambda\kappa}(1+\gamma^5)u^\kappa_j) - m_u^\kappa(\bar{d}^\lambda_jC^\dagger_{\lambda\kappa}(1-\gamma^5)u^\kappa_j] - \tfrac{g}{2}\tfrac{m_u^\lambda}{M}H(\bar{u}^\lambda_ju^\lambda_j) - \tfrac{g}{2}\tfrac{m_d^\lambda}{M}H(\bar{d}^\lambda_jd^\lambda_j) + \tfrac{ig}{2}\tfrac{m_u^\lambda}{M}\phi^0(\bar{u}^\lambda_j\gamma^5u^\lambda_j) - \tfrac{ig}{2}\tfrac{m_d^\lambda}{M}\phi^0(\bar{d}^\lambda_j\gamma^5d^\lambda_j)$$

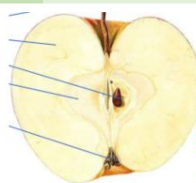
5
$$+ \bar{X}^+(\partial^2 - M^2)X^+ + \bar{X}^-(\partial^2 - M^2)X^- + \bar{X}^0(\partial^2 - \tfrac{M^2}{c_w^2})X^0 + \bar{Y}\partial^2Y + igc_wW^+_\mu(\partial_\mu\bar{X}^0X^- - \partial_\mu\bar{X}^+X^0) + igs_wW^+_\mu(\partial_\mu\bar{Y}X^- - \partial_\mu\bar{X}^+Y) + igc_wW^-_\mu(\partial_\mu\bar{X}^-X^0 - \partial_\mu\bar{X}^0X^+) + igs_wW^-_\mu(\partial_\mu\bar{X}^-Y - \partial_\mu\bar{Y}X^+) + igc_wZ^0_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) + igs_wA_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) - \tfrac{1}{2}gM[\bar{X}^+X^+H + \bar{X}^-X^-H + \tfrac{1}{c_w^2}\bar{X}^0X^0H] + \tfrac{1-2c_w^2}{2c_w}igM[\bar{X}^+X^0\phi^+ - \bar{X}^-X^0\phi^-] + \tfrac{1}{2c_w}igM[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + igMs_w[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + \tfrac{1}{2}igM[\bar{X}^+X^+\phi^0 - \bar{X}^-X^-\phi^0]$$



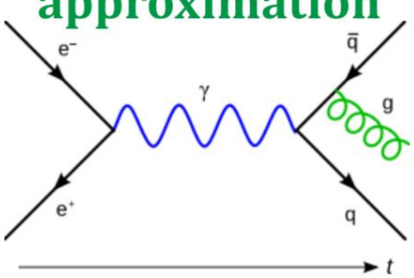
pertubative approximation

algebra

structure



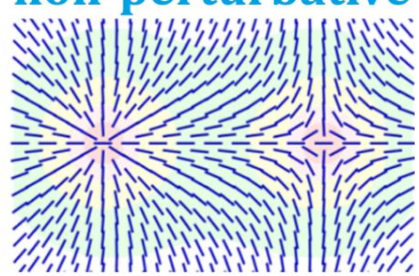
asking deeper questions

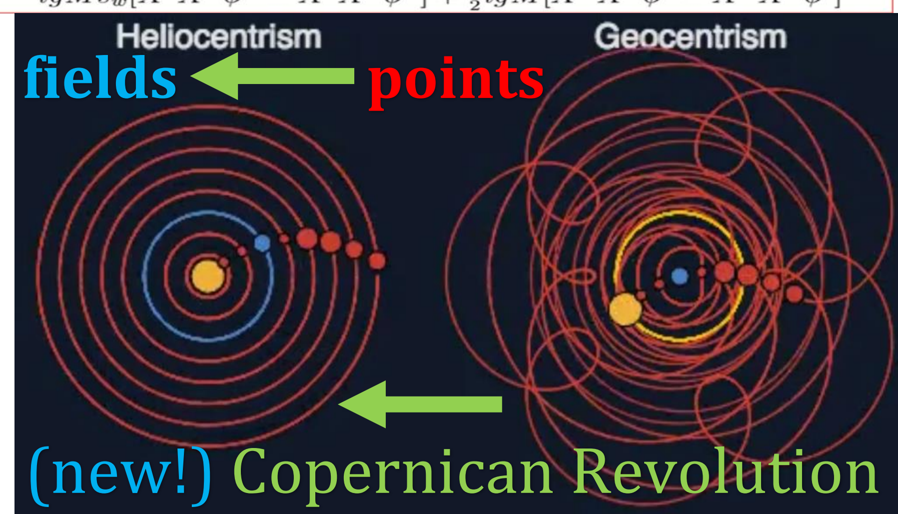


Feynman diagram

its field structure

non-perturbative



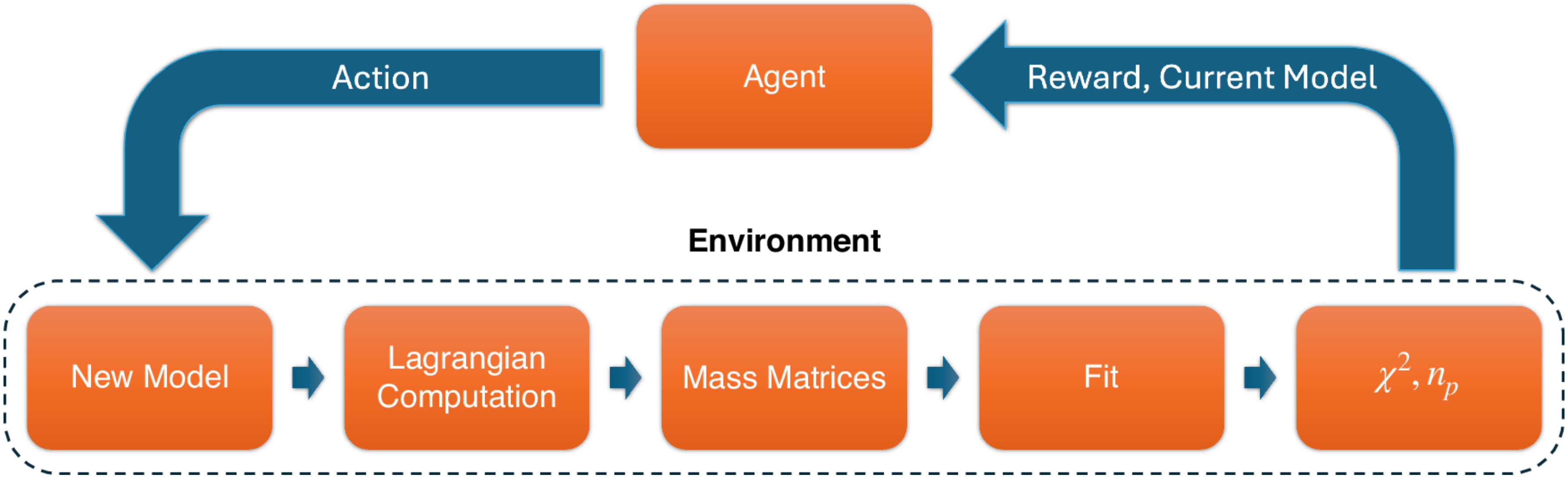


Nonperturbative Lagrangians: look simple, hard to simulate

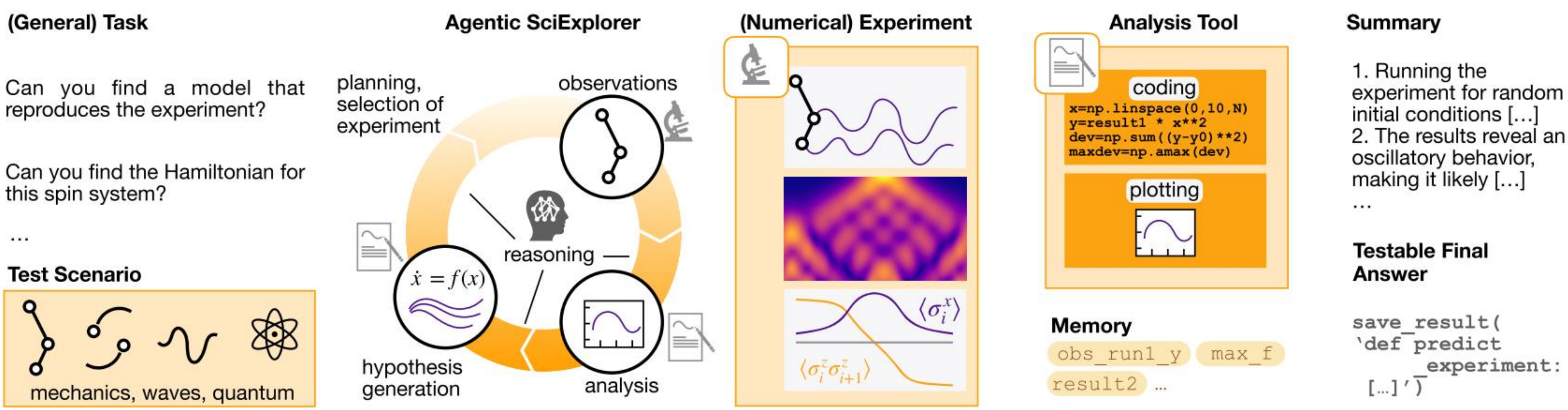
e. g. $\mathcal{L} = -F_{\mu\nu\alpha\beta}F^{\mu\nu\alpha\beta} - V_{\sim\mathrm{Higgs}}(M)$ for $F_{\mu\nu\alpha\beta} = \left[\partial_\mu M, \partial_\nu M\right]_{\alpha\beta}$ **AI can help**

If human models insufficient, **AI can improve, search** e.g. evolutionary style

Towards AI-assisted neutrino flavor theory design: nature.com/articles/s42005-026-02627-2



Agentic Exploration of Physics Models: journals.aps.org/prx/abstract/10.1103/xnqc-q6nt

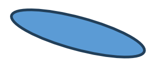


Properties to test for SM + gravity?

Charge quantization: why not $e \to e/2 + e/2$

Coulomb, **Lorentz covariance** → **magnetism**

running coupling (Universe, Phys. Rev. D)

½ spin: same field by π rotation e.g.: 

"time crystals": (3) neutrino oscillations,

electron: angular momentum, Klein-Gordon

magnetic dipole, Larmor precession

3 leptons, muon/taon decay → neutrinos,

para/ortho-positronium → 2/3 photons

$m_{e^+} \ll m_{p^+} < m_{\text{neutron}}$ **of + core/- shell**

beta decay, Cornell potential $+\sim 1\text{GeV/fm}$

$m_d < m_p + m_n$, **quadrupole electric mom.**

larger nuclei, levels, decays e.g. beta, halos

pion, kaon, decays, e.g. $\Lambda^0 \to p^+ + \pi^-$

masses/energy, CKM, PMNS, SM param.

Newton (→GEM), light bend., time dilation

Criteria	M5	M7	M4	M6	M8	regime
PARTICLE - ELECTRON						
Charge quantization	✅	⚠️	❌	⚠️	🚧	static
Electron rest energy (mass)	✅	⚠️	⚠️	❌	🚧	static
de Broglie clock (Zitterbewegung)	✅	⚠️	🚧	⚠️	🚧	dynamic
Particle stability (Derrick escape)	✅	⚠️	⚠️	✅	🚧	dynamic
Magnetic moment μ (g ≈ 2, magnetostatics)	❌	⚠️	🚧	🚧	🚧	dynamic
Angular momentum J (spin ℏ/2)	⚠️	⚠️	🚧	🚧	🚧	dynamic
Spin-½ statistics (720° double cover)	✅	🚧	🚧	🚧	🚧	static
PARTICLE - FULL SPECTRUM						
Antimatter + annihilation	✅	🚧	⚠️	🚧	🚧	both
Neutrinos (neutral states)	⚠️	🚧	⚠️	🚧	🚧	both
Neutrino oscillations (PMNS)	⚠️	🚧	🚧	🚧	🚧	both
Lepton mass spectrum (μ, τ)	⚠️	🚧	❌	❌	🚧	static
Quarks	🚧	🚧	🚧	🚧	🚧	static
Baryons: bound state (p, n)	⚠️	🚧	⚠️	🚧	🚧	static
Baryons: mass ordering + charge profile	⚠️	🚧	🚧	🚧	🚧	static
Baryons: exact masses	🚧	🚧	🚧	🚧	🚧	static
Deuteron (binding + quadrupole)	🚧	🚧	🚧	🚧	🚧	static
Nuclear structure (levels, halos)	🚧	🚧	🚧	🚧	🚧	both
Mesons (π, K)	🚧	🚧	🚧	❌	🚧	static
Dark matter candidate	🚧	🚧	🚧	✅	🚧	static
FORCES						
Electric force (Coulomb 1/r, electrostatics)	✅	⚠️	❌	🚧	🚧	static
Lorentz covariance (+ Coulomb = EM)	⚠️	⚠️	🚧	🚧	🚧	dynamic
Strong force: confinement	⚠️	🚧	🚧	🚧	🚧	static
Running coupling	⚠️	🚧	🚧	🚧	🚧	static

Ideally: **“talk with models” by AI-agents**? perceptive-gleam.lovable.app :

Criterion	M5 Liquid Crystal	M7 HydroBoros	M4 EWT	M6 Ouroboros
Charge quantization	**P Predicted** 0	**PA Partial** 1 (external j0 reservoir)	**NE Negative** 1 (cos source offset)	**PA Partial** 0 in principle (Chern-
(mass)	1 (r_0 = 2.2132 fm pinned to 0.511 MeV)	H/Q = 1.6890 (window-defined)	analytic EWT eqs, not in-sim	M6.2 gate: 8/8 audit fail
de Broglie clock (Zitterbewegung) “time crystal”	**C Calibrated** per-lepton scale (geo-mean anchor)	**PA Partial** fixed-ω by construction	**PL Planned** —	**PA Partial** e^{iωt} ansatz; L/Q=ω definitional
Particle stability (Derrick escape)	**P Predicted** 0 after spec fixed	**PA Partial** harmonic-frame verified; real-time blocked (Q14)	**PA Partial** standing-wave lock-in at perfect placement	**P Predicted** 0 (neutral only)
Magnetic moment μ + spin J Larmor prec.	**PA Partial** spin J at ~1%; g negative	**PA Partial** j_z=1 clean; μ_B blocked on charge unit	**PL Planned** —	**PL Planned** paper-level only
Spin-½ statistics (720° double cover) 	**P Predicted** 0	**PL Planned** —	**PL Planned** scalar field, no spinor structure	**PL Planned** —
Antimatter + annihilation	**C Calibrated** seed geometry (pair sep, phase)	**PL Planned** blocked by Q14 vacuum tachyon	**PA Partial** with assists (threshold, damping, clamp)	**PL Planned** Q_CS=−1 positron identified
Neutrinos with oscillations	**PA Partial** PMNS from SO(3), δ_CP=180° parameter-...	**PL Planned** —	**PA Partial** K=2,8,10 stability open	**PL Planned** —
Lepton mass spectrum	**PA Partial**	**PL Planned**	**NE Negative**	**NE Negative**

Liquid crystal long-range interactions due to nontrivial vacuum like for Higgs $V(\vec{n}) = (|\vec{n}|^2 - 1)^2$

$F \sim 1/D$: "Annihilation dynamics of topological defects induced by microparticles in nematic liquid crystals" Soft Matter

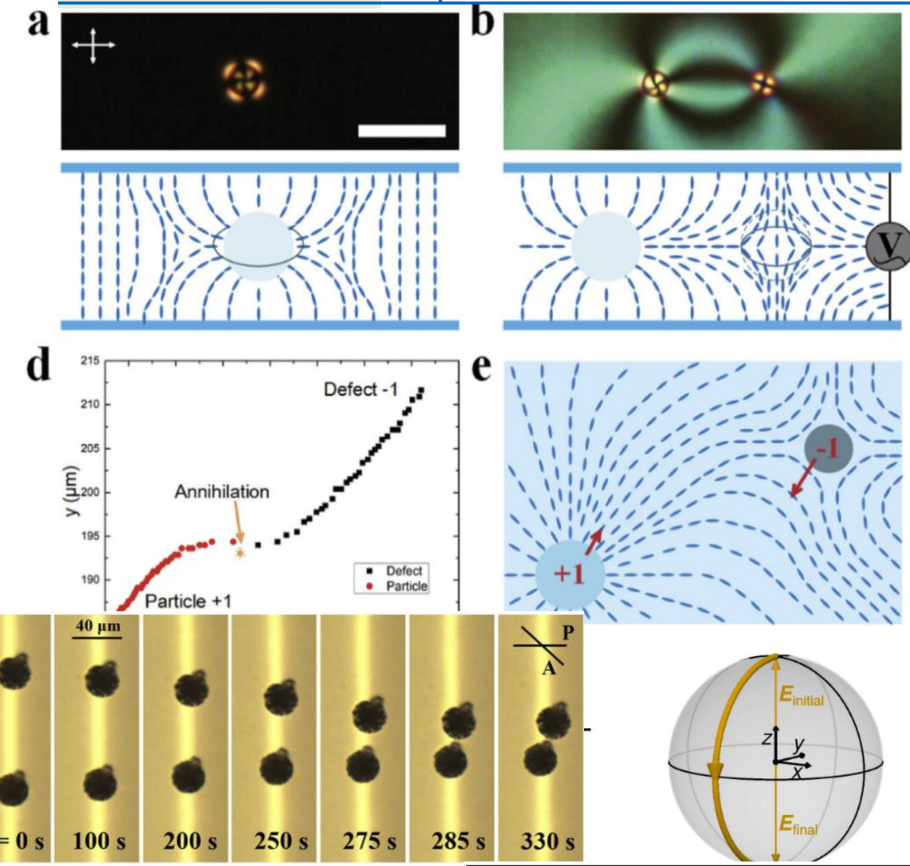
Coulomb: "**Coulomb**-like interaction in nematic emulsions induced by external torques exerted on the colloids" PRE

"**Coulomb**-like elastic interaction induced by symmetry breaking in nematic liquid crystal colloids" Scientific Reports

dipole-dipole: "Novel Colloidal Interactions in Anisotropic Fluids" Science **repulsion** Nature

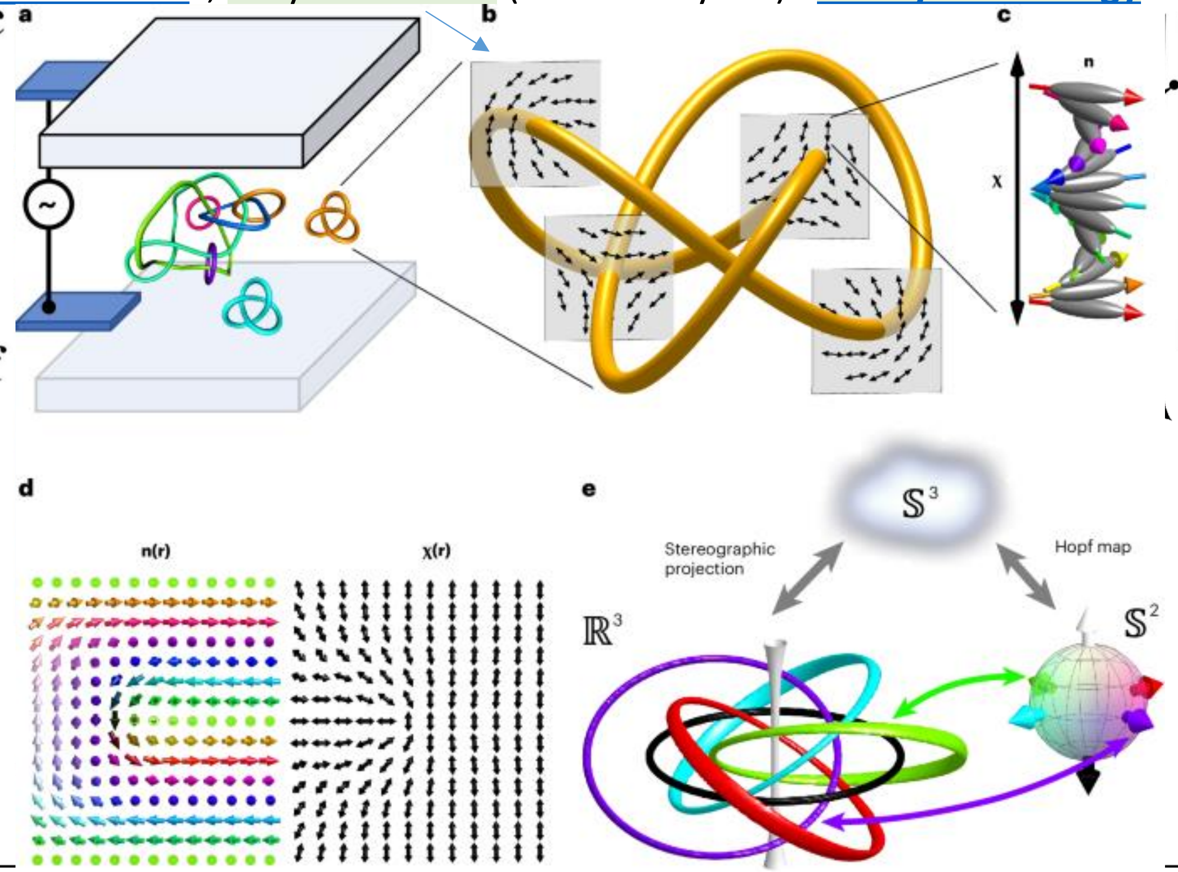
quadrupole-quadrupole: "**Long-range forces** and aggregation of colloid particles in a nematic liquid crystal" PRE

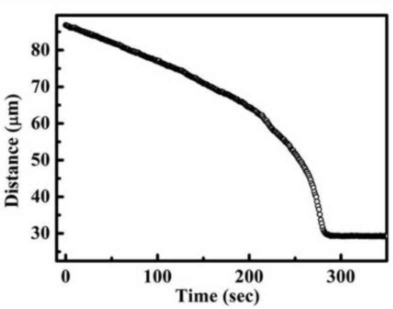
"**Fusion and fission** of particle-like chiral nematic vortex knots", baryon number (Nature Physics) **EM-hydro analogy**



c

f





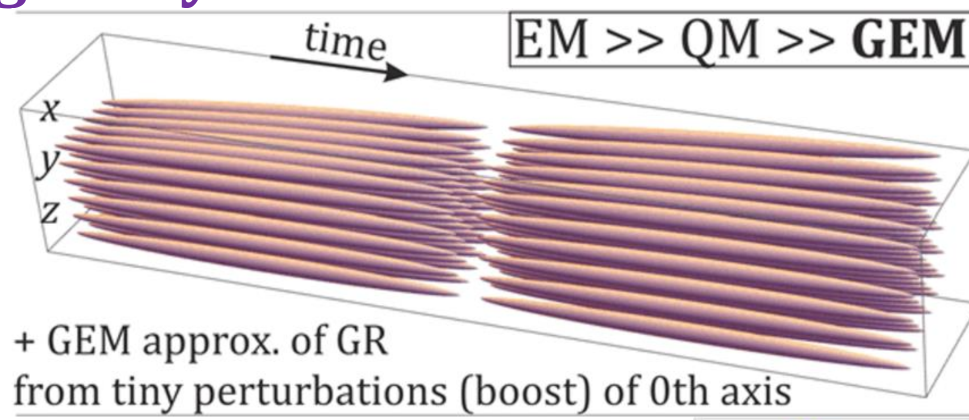
Theory	Gauge fields	Circulation	Gauge condition	Matter field
Electro-dynamics	φ , $\vec{A}$ four-potential	$\vec{B} = \vec{\nabla} \times \vec{A}$ magnetic f.	$\vec{\nabla} \cdot \vec{A} + \frac{1}{c^2}\frac{\partial \varphi}{\partial t} = 0$	$\vec{E}_e = -\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\varphi$
Hydro-dynamics	$\chi = v^2/2, \vec{v}$ flow velocity	$\vec{\omega} = \vec{\nabla} \times \vec{v}$ vorticity	$\vec{\nabla} \cdot \vec{v} + \frac{1}{c_s^2}\frac{\partial \chi}{\partial t} = 0$	$\vec{E}_h = -\frac{\partial \vec{v}}{\partial t} - \vec{\nabla}\chi$

Gauss law should give $e\mathbb{Z}$ –interpreting **field curvature as electric field, F^***

Electric charge = $\oint_S E \cdot dA = \frac{e_0}{4\pi}\oint_{S(u,v)} du\, dv\, (\partial_u \vec{n} \times \partial_v \vec{n}) \cdot \vec{n}$ = **topological**

Teleparallelism – "attempt by Albert Einstein to base a **unified theory of electromagnetism and gravity**" – **let's make it work!**

Tetrad: 4 orthogonal vectors, like liquid crystal Landau-de Gennes model



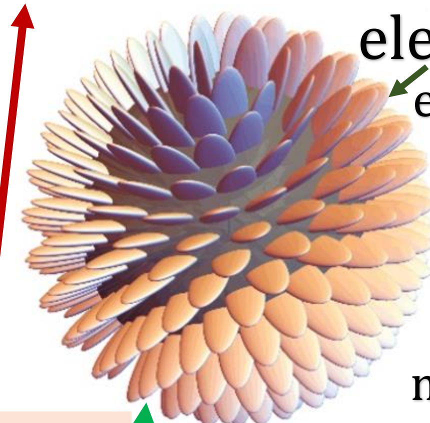
combine 3 (space) or 4 (+time) vectors $\vec{n}$ into real tensor field:

$$\boldsymbol{M = \sum_i \lambda_i\, \vec{n}_i\, n_i^T \approx O(g_{\gg 1}, 1, \delta_{\sim\hbar}, 0)O^T}$$

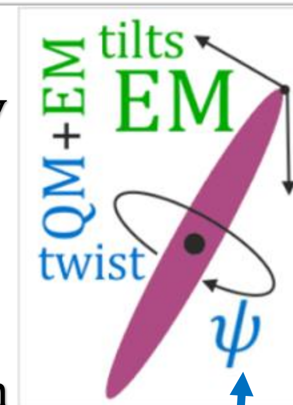
dynamics:

$$O^T \partial_\mu O = \begin{pmatrix} 0 & \tilde{\Gamma}^1 \text{ boost} & \tilde{\Gamma}^2 & \tilde{\Gamma}^3 \\ \tilde{\Gamma}^1 & 0 & -\Gamma^3 & \Gamma^2 \\ \tilde{\Gamma}^2 & \Gamma^3 \text{ tilt} & 0 & -\Gamma^1 \\ \tilde{\Gamma}^3 & -\Gamma^2 \text{ tilt} & \Gamma^1 \text{ twist} & 0 \end{pmatrix}$$

$O \in SO(1,3)$

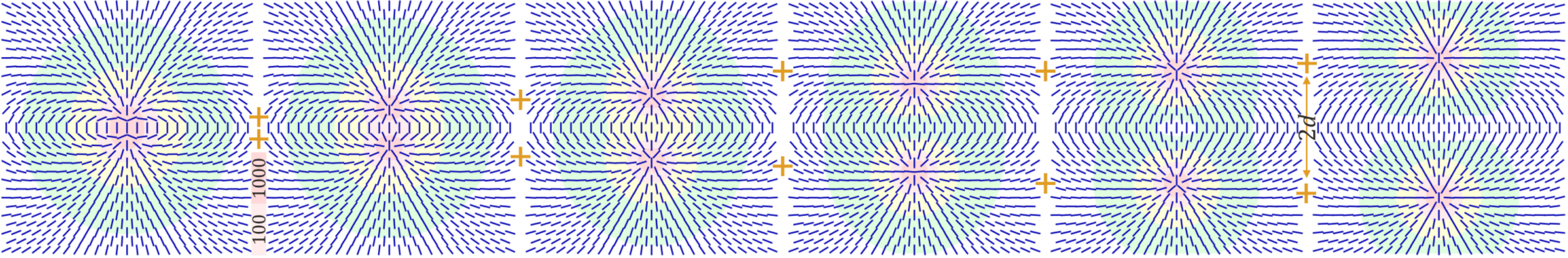


electron?
elementary charge + dipole, angular momentum



- tiny **boosts** of longest **time axis** give **GEM** (gravitoelectromagnetism)
- **tilts** of 2nd axis give **EM with topologically quantized charge**
- low energy **twists** around 2nd: **quantum phase** with ~Klein-Gordon

Various energy: $\boldsymbol{L_{QED} = -\hbar c\, \bar{\psi}\gamma^\mu D_\mu \psi - mc^2 \bar{\psi}\psi - F_{\mu\nu}F^{\mu\nu}/4}$

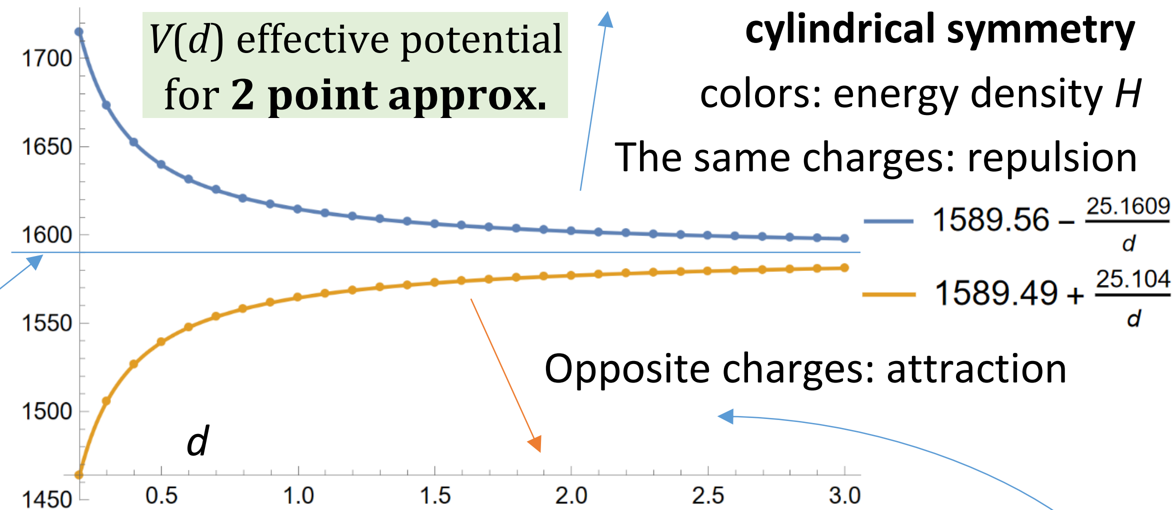


Field energy: ~Coulomb potent.

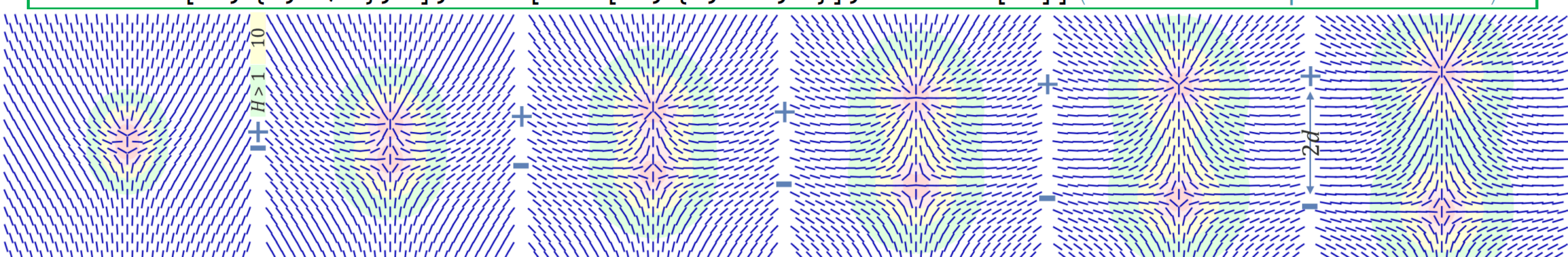
$$E \approx \frac{m_0}{\sqrt{1-v_1^2}} + \frac{m_0}{\sqrt{1-v_2^2}} + V(d)$$

3D, **cutoff** ϵ around singularities: to be **regularized** to rest masses

Lorentz inv.: SRT scaling, magnetism




```
cos = 1 + (z - d) / Sqrt[(z - d)^2 + r^2] - (z + d) / Sqrt[(z + d)^2 + r^2];  (*Manfried Faber dipole ansatz*)
n = {Sqrt[1 - cos^2] x / r, Sqrt[1 - cos^2] y / r, cos} /. r → Sqrt[x^2 + y^2];  (* cylindrical symmetry *)
M = KroneckerProduct[n, n]; dM = {D[M, x], D[M, y], D[M, z]};  (*vector n → matrix M field*)
H = Simplify[Sum[Total[(dM[[i]].dM[[j]] - dM[[j]].dM[[i]])^2, 2], {i, 2}, {j, i + 1, 3}]]; (*Hamilitonian*)
Es = Table[{d, NIntegrate[4 Pi * x (H /. {y → 0}) * Boole[x^2 + (z - d)^2 > 0.001],  (* 0.001 cutoff *)
    {x, 0, Infinity}, {z, 0, Infinity}]}, {d, 0.1, 3, 0.1}]; (*integrate H: total field energy*)
ft = Fit[Es, {1, 1 / d}, d]; Show[Plot[ft, {d, 0.2, 3}], ListPlot[Es]] (*fit Coulomb potentential*)
```



en.wikipedia.org/wiki/Time_crystal: "oscillating in lowest-energy state"
like electron angular momentum (m), neutrino oscillations (m_1, m_2, m_3)

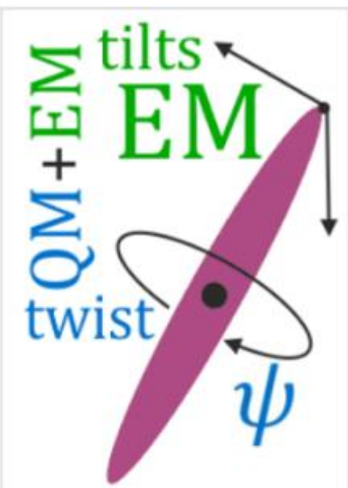
$E = mc^2$ in $\psi \propto \exp(-iEt/\hbar)$ - literally propelled by mass of particle

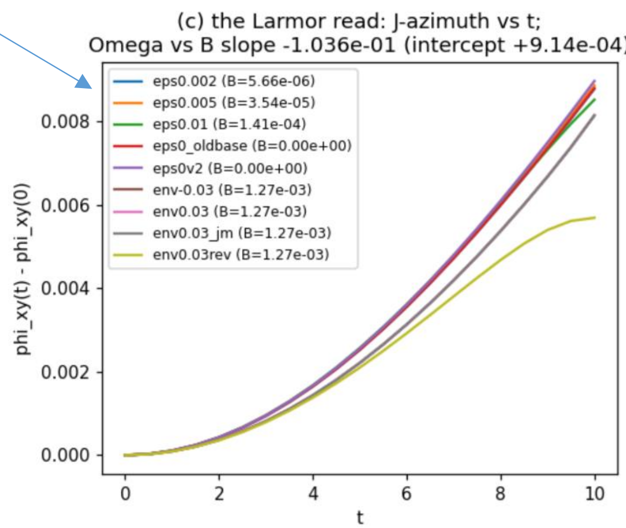
4D liquid crystals: $-\left(\Gamma_0^1 \tilde{\Gamma}_\mu^i - \Gamma_\mu^1 \tilde{\Gamma}_0^i\right)^2$ **negative Hamiltonian terms preferring nonzero time derivatives Γ_0 in presence of mass: boosts $\tilde{\Gamma}$.**

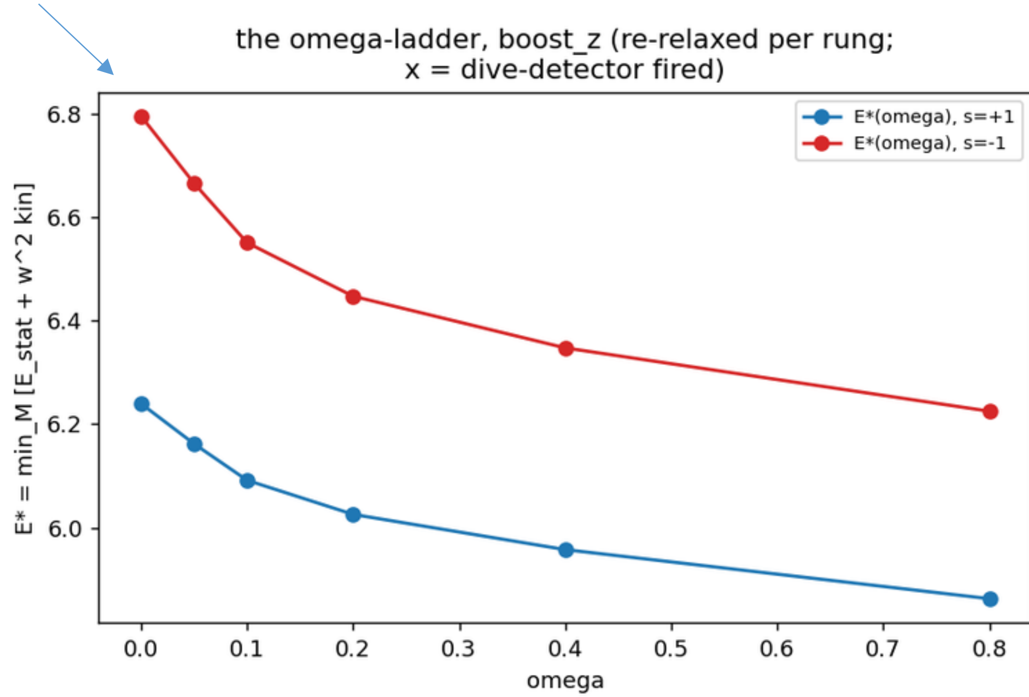
Fable $E(\omega)$ minimization for electron, **should give $E = mc^2 = \hbar\omega$**

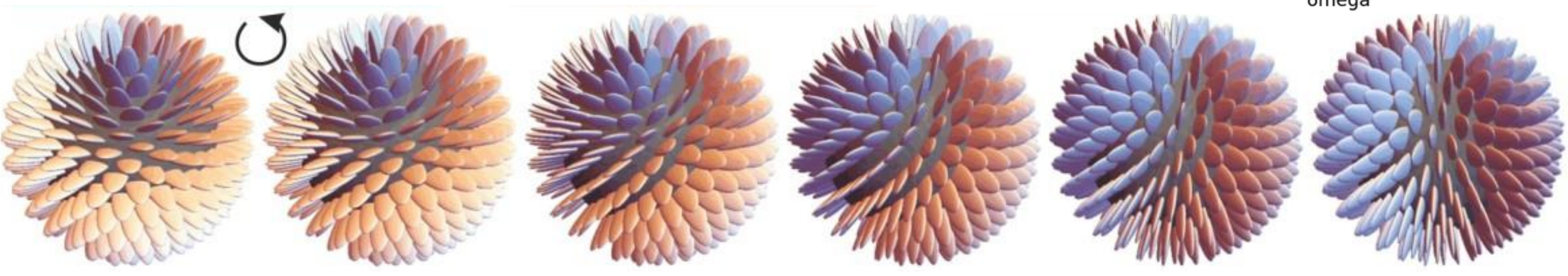
Klein-Gordon derivation for twists ψ

Test of $\omega(B)$ Larmor precession









electron clock(?): phase ψ time evolution

Leptons: hedgehog of 1 of 3 axes

E.g. Fable **muon → electron decay**

indeed releasing energy (not γ)

difference only as neutrinos:

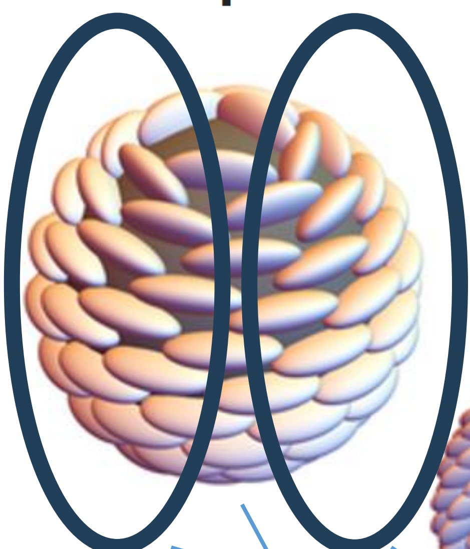
topological vortex knots

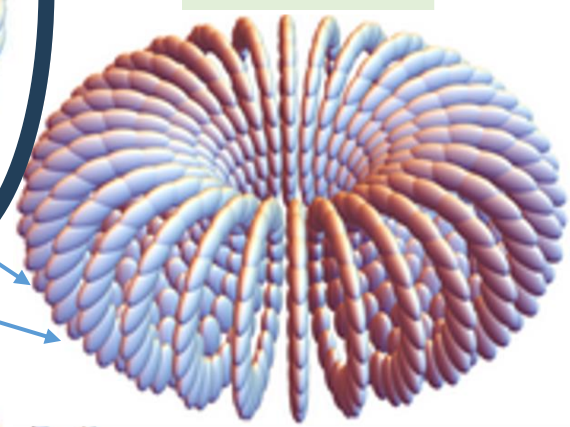
$$\mu^- \rightarrow e^- + \nu_e + \nu_\mu$$

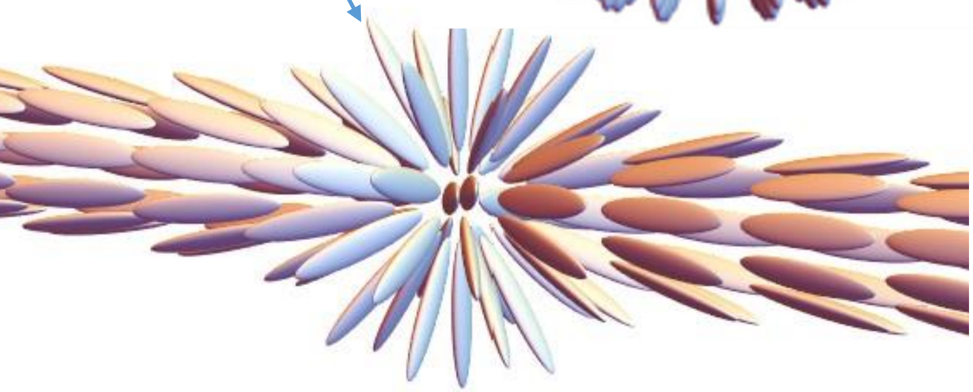
What fields?

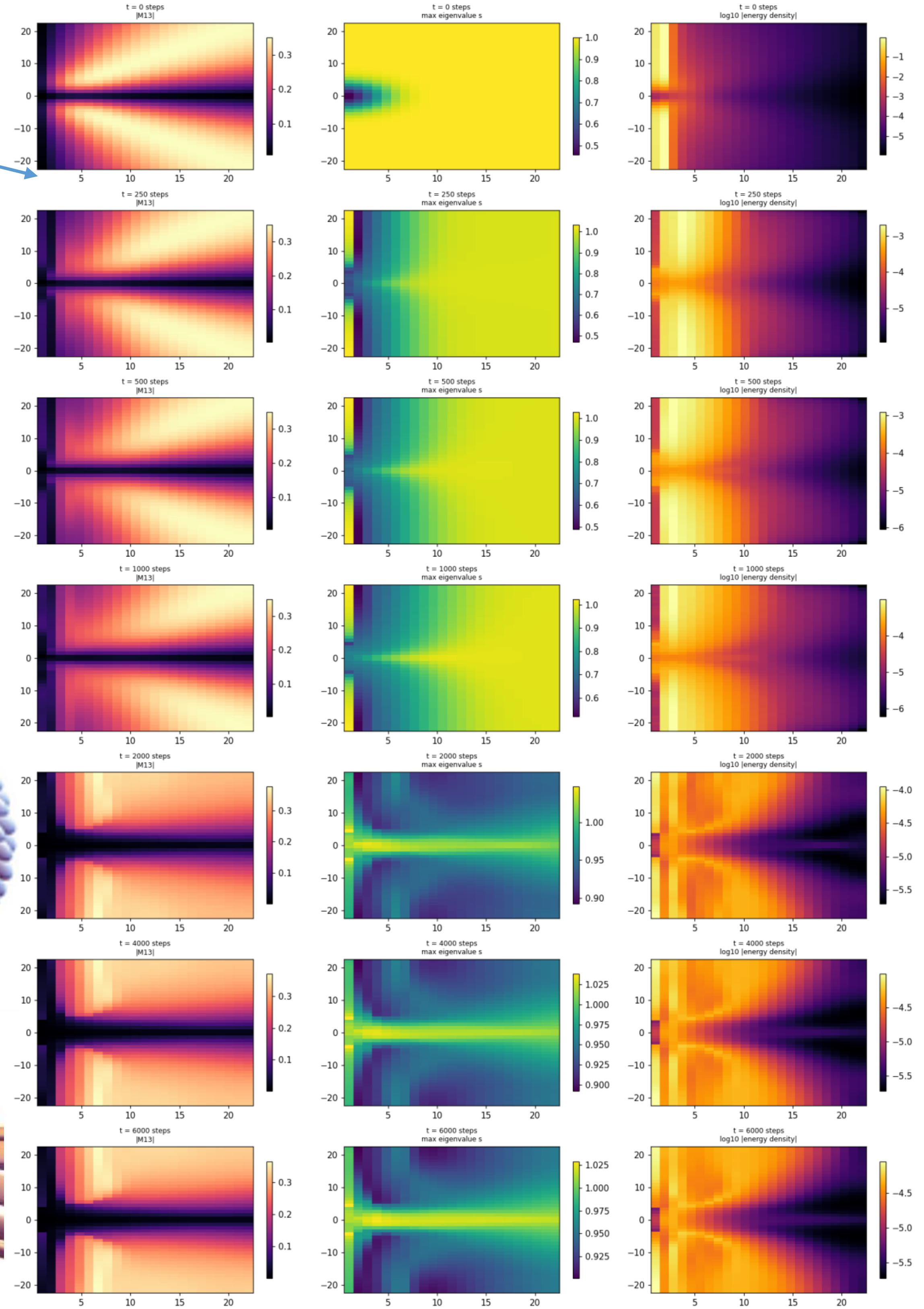
rapid field

rotation?



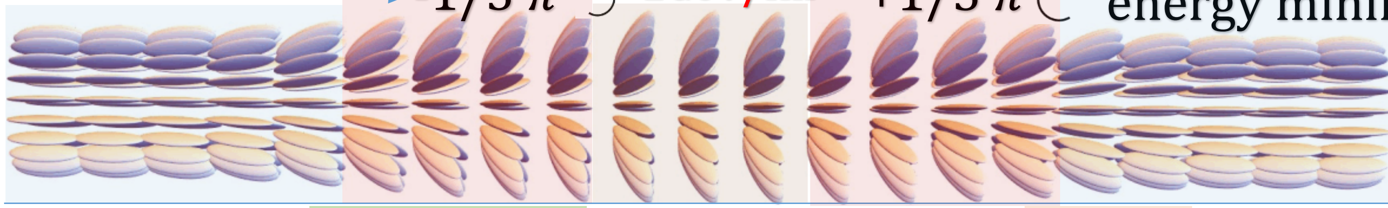




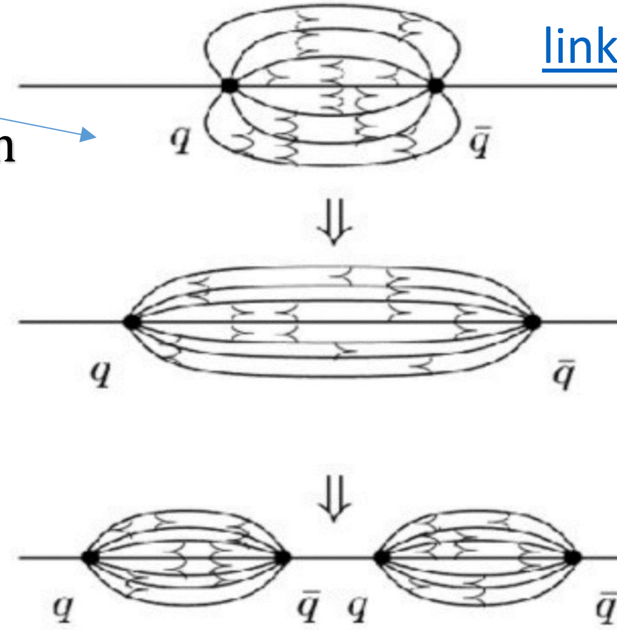


Quark-antiquark, string/QCD flux tube: [Abrikosov vortex](link)

$-1/3\,\pi$ ~1GeV/fm $+1/3\,\pi$ energy minimum



link



Binding of halo nuclei like **Boron-8** with **proton** for 770ms

Ne-17: 2 halo **protons** 109ms, **1p P-26, 2p S-27** 44,16ms

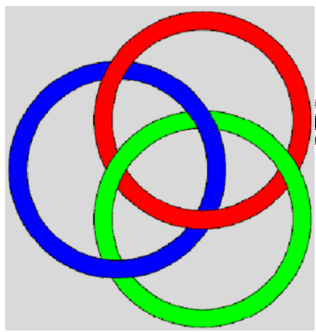
Li-11: 8.6 ms lifetime in ~5 fm distance

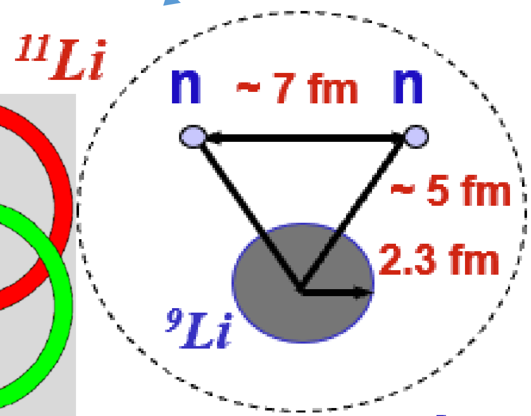
Efimov state field conf.?

Borromean halo nuclei

requiring **3-body forces**

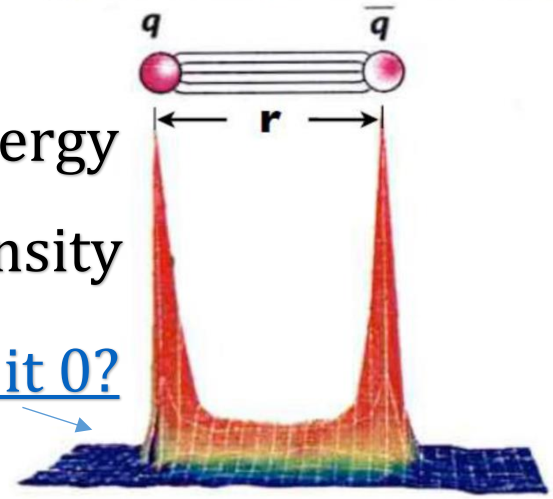
diagrams - He6: He4+nn



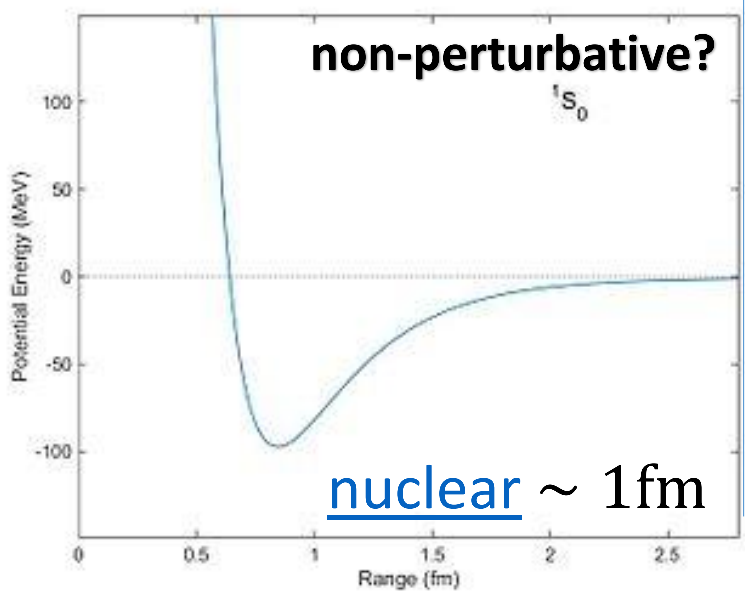


Energy density

is it 0?

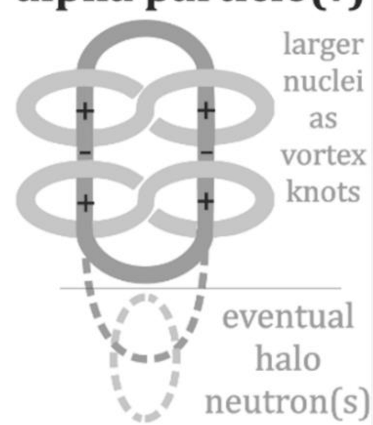


Finally deeper understanding of nuclear physics – e.g. for fusion/fission optimizations



binding larger nuclei?

alpha particle(?)



Many more to **simulate** … **consequences**?

gluon flux tube/color/quark string