Nuclei as Topological Solitons

Bridging the Gap between Quark and Meson Descriptions of Nuclear Physics

I. Semiclassical methods & Effective Meson Theories

II. Baryon and Electromagnetic Currents

III. Application to Deuteron and Alpha Particle

[redacted] Braaten

Semiclassical Expansion: $\hbar \to 0$

Path integral formulation

$$K(T) \equiv \mathrm{Tr}\left(\exp(-iHT/\hbar)\right)$$
$$= \int \mathcal{D}(\phi)\, e^{i/\hbar\, S(\phi)}$$

$\phi_{cl}(\vec{x},t)$ extremizes $S(\phi) = \int d^4x\, \mathcal{L}(\phi)$

Expand $\phi_{fl} = \phi_{cl}(\vec{x},t) + \eta(\vec{x},t)$

Keep η^2 terms $\to 0$

$\Rightarrow$ [illegible]

Modes(ω_i)

But zero modes ($\omega_i = 0$) must be treated more carefully since these modes correspond to large amplitude, collective motion.

Derive Effective Hamiltonian for collective coordinates

Zero point energies from small vibratory modes renormalize couplings ...

Effective Meson Theories

- mesons are important degrees of freedom
- lagrangian fit to symmetries of QCD

Chiral Lagrangians

$$\mathcal{L} = \frac{f_\pi^2}{4} \mathrm{Tr}\left[\partial_\mu U \partial^\mu U^\dagger\right] + \ldots$$

$$U = \frac{1}{f_\pi}\left(\sigma + i\vec{\tau}\cdot\vec{\pi}\right)$$

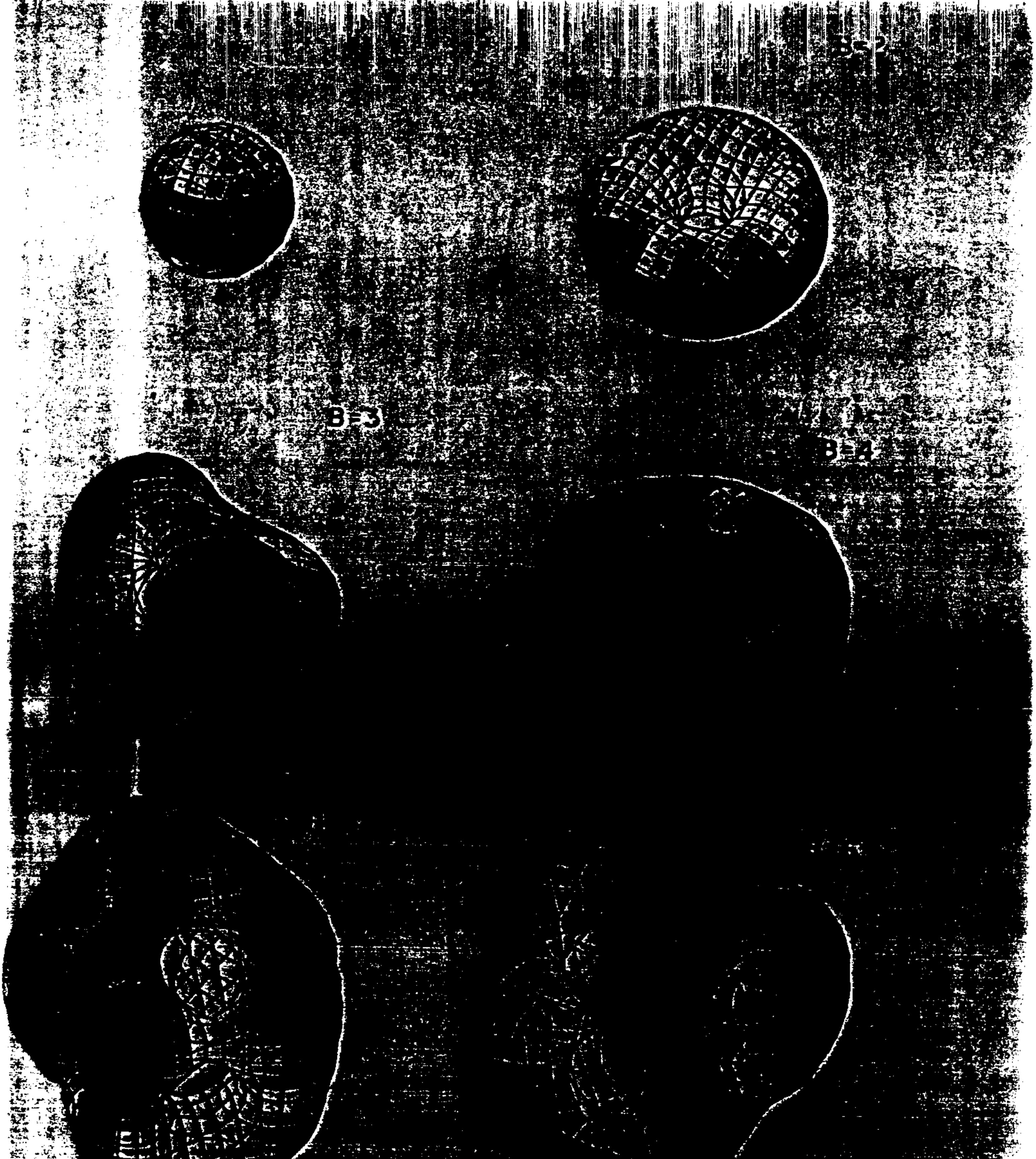
$$U U^\dagger = \mathbb{1}$$

Non-linear sigma model + extensions

Conserved Topological Current

$$B_\mu = \frac{\varepsilon_{\mu\nu\alpha\beta}}{24\pi^2} \mathrm{Tr}\left[(\partial_\nu U U^\dagger)(\partial_\alpha U U^\dagger)(\partial_\beta U U^\dagger)\right]$$

Divides into distinct sectors marked by conserved charge $B_0 \Rightarrow$ baryon number


B-2
B-3
B-4

B = 4 Mo[illegible]oration

Effective Radial Potential for Deuteron