



Chiral symmetry and effective field theories for hadronic, nuclear and stellar matter



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ABSTRACT

Chiral symmetry, first entering in nuclear physics in the 1970s for which Gerry Brown played a seminal role, has led to a stunningly successful framework for describing strongly-correlated nuclear dynamics both in finite and infinite systems. We review how the early, germinal idea conceived with the soft-pion theorems in the pre-QCD era has evolved into a highly predictive theoretical framework for nuclear physics, aptly assessed by Steven Weinberg: “it (chiral effective field theory) allows one to show in a fairly convincing way that what they (nuclear physicists) have been doing all along... is the correct first step in a consistent approximation scheme”. Our review recounts both how the theory presently fares in confronting Nature and how one can understand its extremely intricate workings in terms of the multifaceted aspects of chiral symmetry, namely, chiral perturbation theory, skyrmions, Landau Fermi-liquid theory, the Cheshire cat phenomenon, and hidden local and mended symmetries.

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Contents

1. Prologue	3
2. Introductory survey	4
2.1. Low-energy QCD and chiral symmetry	5
2.1.1. Chiral symmetry and the pion	5
2.1.2. Pseudoscalar meson spectrum	6
2.2. Chiral effective field theory	7
2.2.1. The Nambu–Goldstone boson sector	7
2.2.2. The baryon sector	8
2.2.3. Chiral pion–nucleon effective Lagrangian	8
3. Chiral symmetry and hadron structure	9
3.1. From little bag to chiral bag	9
3.2. Encoding chiral symmetry and confinement in the chiral bag	10
3.2.1. Leakage of baryon charge	11
3.2.2. Flavor-singlet axial charge g_A^0	11

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3.2.3.	Vector dominance.....	13
4.	Chiral symmetry in nuclear many-body systems	14
4.1.	Meson exchanges.....	14
4.2.	Chiral symmetry in meson-exchange currents.....	14
4.3.	Nuclear forces	16
4.3.1.	Two-nucleon forces	16
4.3.2.	Nuclear many-body forces.....	18
4.3.3.	In-medium effective nucleon–nucleon interactions	18
4.3.4.	Role of the $\Delta(1232)$ isobars	20
4.4.	Infinite nuclear matter	21
4.4.1.	Fermi liquid description of nuclear matter.....	24
4.4.2.	Nuclear mean field and the optical potential	27
4.5.	Finite nuclei from density functional methods.....	29
4.5.1.	Density-matrix expansion.....	30
4.5.2.	Two- and three-body contributions	31
4.5.3.	Matching to QCD.....	34
5.	Nuclear chiral thermodynamics.....	34
5.1.	Nuclear phase diagram and liquid–gas transition.....	34
5.2.	Isospin-asymmetric nuclear matter	36
5.3.	Thermodynamics of the chiral condensate	38
5.4.	Functional renormalization group approach to nuclear and neutron matter	40
6.	Hadrons in matter and chiral symmetry restoration: conceptual aspects.....	44
6.1.	Defining Brown–Rho (BR) scaling.....	45
6.2.	Hidden local symmetry (HLS).....	45
6.2.1.	HLS as “emergent symmetry”.....	45
6.2.2.	HLS and fractionization	47
6.3.	Relativistic mean field and BR scaling.....	47
6.3.1.	Trace anomaly: “Soft” and “hard glue”	48
6.3.2.	Relativistic mean field theory and Landau Fermi-liquid theory.....	49
6.4.	Vector manifestation and m_ρ^* as the order parameter for chiral symmetry	49
6.5.	Dilaton and mean field approximation	50
6.6.	Mended symmetries: DLFP and VM	51
6.7.	“Seeing” BR scaling.....	52
6.7.1.	Dileptons	52
6.7.2.	Anomalous orbital gyromagnetic ratio δg_l	53
6.7.3.	Axial charge transitions in nuclei	53
6.7.4.	Nuclear tensor forces.....	54
6.7.5.	Revisiting C14 dating.....	54
6.7.6.	Shell evolution	55
6.8.	Meson condensation in dense matter	55
7.	Implications for nuclear astrophysics.....	57
7.1.	Neutron matter equation of state	57
7.2.	Chiral Fermi liquid description of neutron matter	58
7.3.	Constraints from neutron star observations	59
8.	Skyrmions, dense matter and compact stars	64
8.1.	Skyrmions on a crystal lattice.....	64
8.2.	Skyrmion–half-skyrmion phase change.....	65
8.3.	Role of ρ and ω in nuclear structure	67
8.3.1.	BPS skyrmions and heavy nuclei	67
8.4.	Modified BR scaling and tensor forces.....	68
8.5.	Symmetry energy and compact stars	68
9.	Concluding remarks and outlooks	70
	Acknowledgments	71
	References.....	71

1. Prologue

This review covers a broad spectrum of mutually related topics, from the symmetry breaking pattern of QCD and the structure of hadrons to various facets of the nuclear many-body problem and to the physics of dense, strongly interacting matter as it is realized in the core of neutron stars. It is written as a tribute to Gerry Brown who pioneered and shaped these fields of research in his own very special style. Each one of the authors benefited greatly from multiple exchanges with Gerry, as senior collaborator over decades (M.R.), as postdoctoral fellow and frequent visitor to Stony Brook (W.W.), and as Gerry’s former Ph.D. student in his later years (J.W.H.), thus representing three generations of researchers inspired by Gerry Brown’s intuitive way of thinking.

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