GAST

(Gauge and String Theories)

Sezione di Pisa

02 July 2020

Coordinatore nazionale: Domenico Seminara (Firenze)
Coordinatore locale: Stefano Bolognesi
Nodi: Bologna, Firenze, Parma, Perugia, Pisa, Trieste

PERSONALE

Stefano Bolognesi (UniPi Professore Associato, Incarico di ricerca INFN)

Kenichi Konishi (UniPi, Associato Eminente INFN)

Marco Barsanti (dottorando Unipi terzo anno)

Andrea Luzio (perfezionando SNS primo anno)

Attività di Ricerca 2020-2021

-Sigma models, Large-N, Topological solitons.

The two-dimensional CP(N) sigma model is interesting as an analogous model for nonperturbative dynamics of QCD, possessing asymptotic freedom and confinement; it can also be related to some phenomena in condensed matter physics. We recently examined analytically the large-N gap equation and its solution for spaces, in particular compact ones, with and without boundaries. We plan to continue these investigations and hopefully extend these insights to different types of spaces and boundary conditions, different sigma models and higher dimensions.

-Gauge theories (non-perturbative aspects), (Generalized) Symmetries and Anomalies, Dynamics of chiral gauge theories.

In spite of the bulk of knowledge accumulated after almost half-century of studies of vectorlike gauge theories such as SU(3) quantum chromodynamics (QCD), surprisingly little is known today about strongly coupled ordinary (nonsupersymmetric) chiral gauge theories. Many questions can be asked in these types of theories. Answers, or at least constraints on possible answers, can be obtained with the use of standard or new techniques such as 't Hooft anomaly matching conditions.
Recently the concept of generalized symmetries has been applied to Yang-Mills theories and QCD like theories, to yield new, stronger, version of 't Hooft anomaly matching constraints. Mixed 't Hooft anomalies between 1-form symmetries and some 0-form (standard) discrete symmetries provide useful information about the infrared dynamics of the system. In some cases, they give decisive indication to select only few possibilities for the infrared phase of the theory.

-Gauge-Gravity duality and applications, Topological solitons.

Using the Witten-Sakai-Sugimoto (WSS) model, the top-down holographic theory closest to QCD, some open strong-coupling problems can be addressed using analytic techniques. Nuclear physics aspects have not been developed in sufficient detail. Our main tool is the well-known relation between WSS model and Skyrme model. We plan to continue in these directions, expanding all possible links between the holographic QCD and Skyrme model.

GSS – Pi 2020

Coord. Naz.: Anna CERESOLE (INFN, Torino)

Coord. Pisa: A. SAGNOTTI (Scuola Normale)

Italian Nodes

Genova, Lecce, Milano, Milano Bicocca, Padova, Pisa, Torino

Members of the Pisa Node

- **Staff members**
  - Augusto Sagnotti (Full Professor)
  - Karapet Mkrtchyan (RTDA)
- **Other participants**
  - Sergio Ferrara (Senior associate of LNF)
  - Dario Francia (Centro Fermi, Roma Tre)
  - Ehsan Hatefi (Post Doc, will stay until the Fall of 2021)
  - Yoshiyuki Tatsuta (PRIN Postdoc, will begin in the fall of 2020)
  - Kirill Zatrimaylov (PhD student, will stay until the fall of 2021)

Research Program

- **Supersymmetry breaking by fields and branes:**

Non-linear realizations of supersymmetry and their microscopic origin in String Theory, in “brane supersymmetry breaking”. Supersymmetry Breaking in Supergravity and String Theory, with stability issues in compactifications and applications to Early-Universe Cosmology.

- **Higher Spins:**

Lagrangian form for 3D higher-spin theories and covariant action principles for chiral p-form fields

NPQCD

NONPERTURBATIVE PROPERTIES OF QCD

Preventivi 2021 Pisa, 2 Luglio 2020

Proprietà non-perturbative della QCD: confinamento del colore, simmetrie chirali, proprietà topologiche, diagramma di fase della QCD, QCD in campi esterni, teorie efficaci, scattering adrone-adrone, proprietà dell'assione, etc.

Simulazioni numeriche su reticolo: sviluppo di codici su architetture parallele standard ed ibride (CPU+GPU o altro), exascale (legame con progetto HPC-HTC, CIPE).

- **Sezioni partecipanti:** Bari, Cosenza (+ LNGS), Ferrara, Pisa
- **Responsabile nazionale:** L. Cosmai (Sez. INFN di Bari)
- **Associati presso Pisa:**
  - B. Alles Salom (Ricercatore INFN, 100% NPQCD)
  - C. Bonati (RTDB, 85% NPQCD)
  - M. D'Elia (Prof. Ordinario, 85% NPQCD)
  - E. Meggiolaro (Prof. Associato, 100% NPQCD [responsabile locale])
  - G. Paffuti (Prof. Ordinario, 100% NPQCD)
  - P. Rossi (Prof. Ordinario, 100% NPQCD)
  - A. Di Giacomo (Prof. Emerito, associato eminente)
  - A. Athenodorou (borsista *Marie Curie*, 100% NPQCD)
  - C. Bonanno, M. Cardinali, G. Clemente, L. Maio (Dottorandi, 100% NPQCD)
  - P. Giudice, F. Negro (Docenti MIUR, 50% NPQCD)

Iniziativa specifica INFN
SFT, Statistical Field Theory

Elenco **sedi INFN nazionali** e responsabili locali

Trieste (Giuseppe Mussardo - coordinatore nazionale)

Firenze (Andrea Cappelli)

Milano (Luca Molinari)

Torino (Roberto Tateo)

Cosenza (Domenico Giuliano)

Pisa (Davide Rossini) →

Genova (Nicodemo Magnoli)

Sede di Pisa:

Enore **Guadagnini** (UniPi, PO, 100%)
Michele **Mintchev** (INFN, Senior, 100%)
Davide **Rossini** (UniPi, PA, 90%)
Ettore **Vicari** (UniPi, PO, 100%)
Alessandro **Vichi** (UniPi, PA, 100%)
Omar **Zanusso** (UniPi, RTDA, 100%)

Argomenti di ricerca:

- Quantum field theories out of equilibrium
- Entanglement and quantum information dynamics
- Topological phases of matter, field theories and duality
- Conformal invariance, phase transitions and universality classes
- Low-dimensional quantum field theory: integrability and its breaking

Iniziativa Specifica NUCSYS

Title: The strongly correlated nuclear system: effective interactions, models, reactions, fundamental symmetries and applications

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Responsabile Nazionale: Alejandro Kievsky

Unità e Responsabili Locali:

- Lecce: Luca Girlanda
- Padova: Luciano Canton
- Pavia: Carlotta Giusti
- Pisa: Alejandro Kievsky
- Torino: Maria Benedetta Barbaro
- Trento: Winfried Leidemann

Composizione dell'unità di Pisa:

Alejandro Kievsky (PR, afferenza al 100%)
Laura E. Marcucci (PA, afferenza al 100%)
Michele Viviani (PR, afferenza al 100%)

Temi di ricerca:

The present project results from a partial merging of two previous INFN projects: Few-Body Systems (FBS) and Many-Body Systems (MANY BODY), both of them intended to describe particular aspects of atomic nuclei which are relevant for the progress in the knowledge of fundamental interactions.

Argomenti seguiti principalmente a Pisa:

● Ab-initio approaches in few-nucleon systems to validate and constrain our modern understanding of the nuclear interaction and the interaction of nuclei with external probes, based on the (chiral) effective field theory (EFT) paradigm.

● Implementation of the contact three-nucleon interaction to solve discrepancies observed in polarization observables in three- and four-nucleon systems at low energies.

● Use of the pionless approach to the nuclear interaction, valid at much lower energies, in connection to universal properties of weakly bound systems.

● Systematic study of nuclear processes of astrophysical interest, as for example the A=3-6 radiative captures, of relevance for the theory of the Big Bang Nucleosynthesis.

● Accurate calculations of parity and/or time-reversal violating observables in light nuclei that will allow, when confronted to on-going experimental efforts worldwide, to address the structure of hadronic parity violation or fundamental issues like identifying sources of CP violation beyond the Standard Model.

Richieste alla sezione:

- Incontro Nazionale di Fisica Nucleare Teorica (Cortona)
  Ottobre 2021

- Electron-Nucleus Scattering (Marciana Marina)
  Giugno 2021

Queste attività sono da confermare!

Iniziativa specifica: NEUMATT

Titolo:

Neutron star matter

Research line: Astro-Particle Physics

Topics

Nuclear matter in neutron stars; Quark matter; Nuclear physics aspects of novae, supernovae, and other explosive environments; Mergers of Compact stars; Neutron star crust.

Proposed activities of the Pisa Research Unit

Equation of state of nuclear matter at finite temperature,
Newborn neutron stars and postmerger compact objects,
Hypernuclei, hyperons in dense matter and in neutron stars,
Quark deconfinement phase transition in binary neutron star mergers

Iniziativa specifica: NEUMATT

Sezioni INFN partecipanti e responsabili locali:

- Sez. di Ferrara: Alessandro Drago (responsabile nazionale)
- Sez. di Catania: Hans-Josef Schulze
- LNGS: Giulia Pagliaroli
- Sez. di Milano: Pierre Pizzochero
- Sez. di Pisa: Ignazio Bombaci

Partecipanti sezione di Pisa

- **Ignazio Bombaci (80%)**
- **Domenico Logoteta (RTDa 80%)**

Iniziativa specifica TAsP (Theoretical Astroparticle Physics)

(coordinatore nazionale Fiorenza Donato)

Sedi nazionali (12):

Bari, Ferrara, Lecce, Lab. Naz. di Frascati, Lab. Naz. del Gran Sasso, Napoli, Padova, Pisa, Pavia, Roma I, Torino, Trieste (circa 90 membri)

Componenti sede di Pisa 2020/2021:

Staff:

Santi Cassisi (dirigente ricerca INAF) 100%,
Michele Cignoni (ric. di tipo B, universitario) 100%,
Scilla Degl'Innocenti (p.a.) 100%, responsabile locale
Dario Grasso (primo ric. INFN) 80%,
Giovanni Marozzi (ric. di tipo B, universitario) 100%,
Paolo Paolicchi (p.a.) 100% (in quiescenza Novembre 2020)
Pier Giorgio Prada Moroni (p.a.) 60%

Tempo determinato:

Chiara Animali (dottoranda fino al 2022)
Matheus Rodrigues Medeiros Silva (dottorando fino al 2022)
Veronica Roccatagliata (ricercatore di tipo A fino a Dicembre 2021)
Lorenzo Sebastiani (assegnista INFN fino a Dicembre 2021)
Tiziano Schiavone (dottorando fino al 2022)

FTE=8.55

+ 5 laureandi (Simone Moser, Filippo Tognini, Simone Veronese, Bruno Sanna, Silvia Alisia Trabucco)

Argomenti di ricerca

Evoluzione stellare teorica:

caratteristiche strutturali delle stelle, studio delle stelle di campo ed in ammasso nella Via Lattea e nelle galassie del Gruppo Locale, modelli solari, modelli sintetici di popolazioni stellari complesse (dovute a più episodi di formazione stellare) in galassie per l'analisi della popolazione di campo nelle galassie e delle regioni di formazione stellare.

Cosmologia teorica:

effetti non lineari in cosmologia: studio della dinamica dell'Universo, a partire dall'era inflazionaria, attraverso osservabili cosmologiche "late type".

Studio dell'origine e propagazione dei raggi cosmici nella nostra Galassia:

modellizzazione delle emissioni multimessenger della Galassia e ricerca indiretta di materia oscura.

Fisica del sistema solare:

studio delle caratteristiche fisiche e dinamiche degli asteroidi del sistema solare con particolare attenzione allo studio degli effetti evolutivi dinamici legati all'interazione con la radiazione solare.

Pubblicazioni: 67 articoli su rivista e 24 pubblicazioni in atti di congresso (2019-2020) + pubblicazioni all'interno delle collaborazioni MAGIC e KM3NeT

Tesi: relatori di 6 tesi di laurea e 2 tesi di dottorato nel periodo 7/2019-7/2020

Pisa group – Biophys (rinnovo IS)

Activity

The activity of the Pisa group is focused on the developments and applications of numerical simulation methods of complex systems of biological interest.

Members (FTE: 5.0)

Name -- Position -- INFN Position

Giuseppe Brancato – Professore Aggregato RU 100%

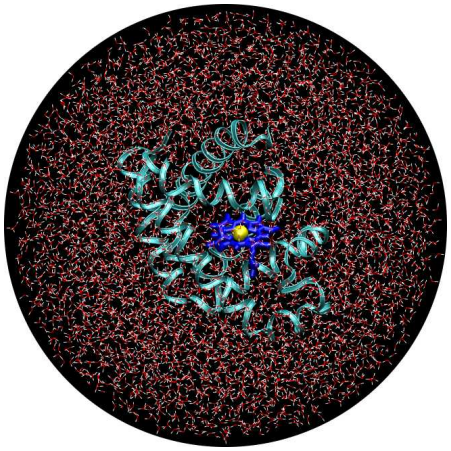
Vincenzo Barone -- Professore Ordinario 100%

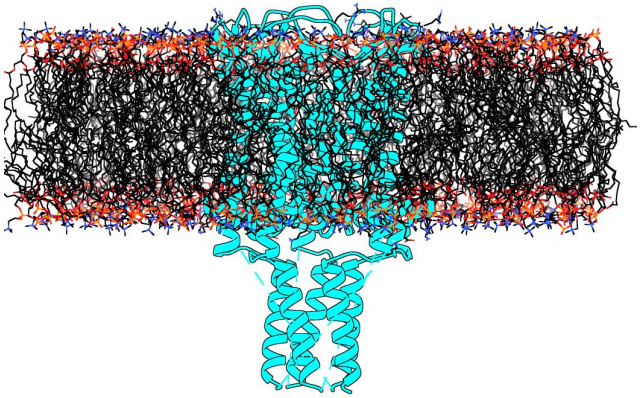
Giordano Mancini -- Tecnico 100%

Sergio Rampino -- Ricercatore Universitario RTDA 100%

Luca Sagresti – Dottorando 100%

Molecular Dynamics (MD) Simulations





Size: >100,000 atoms

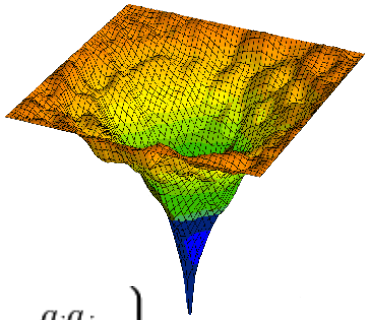
Time scale: 100 ns – 1 μs

Molecular dynamics is a computational method that allows to follow the time evolution of a molecular system on the basis of a known potential

Simulation with full atomistic details:
Protein
Environment (Solvent + Lipid Membrane)

Molecular mechanics force fields

$$V(r^N) = \sum_{\text{bonds}} \frac{1}{2} k_b (l - l_0)^2 + \sum_{\text{angles}} k_a (\theta - \theta_0)^2 + \sum_{\text{torsions}} \frac{1}{2} V_n [1 + \cos(n\omega - \gamma)] + \sum_{j=1}^{N-1} \sum_{i=j+1}^{N} \left\{ \epsilon_{i,j} \left[\left(\frac{\sigma_{ij}}{r_{ij}} \right)^{12} - 2 \left(\frac{\sigma_{ij}}{r_{ij}} \right)^{6} \right] + \frac{q_i q_j}{4\pi\epsilon_0 r_{ij}} \right\}$$



Richieste 2021

Missioni Interne ed esterne: 7.5KE (5.0 FTE)

1) Prof.sa Annalisa Pastore, King's College, UK
2) Prof.sa Armagan Kocer, Univ. Groeningen, NL
3) Prof. Dario Alfé – University College London, UK
4) Prof. Giovanni Bottari – Universidad Autonoma de Madrid, Spain
5) Prof. Eliad Cohen – University of Massachusettes Lowell
6) Dr. Ranieri Bizzarri - CNR

Partecipazione alle seguenti conferenze

1) CECAM Workshop
2) ACS Conferences
3) ESP Conference

Inviti Ospiti Stranieri

Prof. Giovanni Bottari

Universidad Autonoma de Madrid, Spain