Theoretical Physics

Structure and Nuclear Reactions in low and intermediate Energies:

Methods and concepts of field theory and many-body perturbative and variational techniques are applied to the study of nuclear phenomena. In particular it is studied the BRST treatment for collective variables, nuclear deformations and the formation of alpha substructures. In the range of intermediate energies it is studied the electromagnetic structure of the hyperons with solitonic models. Additionally, it is analyzed the density of dark matter of the Universe with models that use different possibilities of weak-interacting particles

Chaos and Complex Systems

It is analyzed the quantum properties of systems that are classically chaotic.

It is studied the semiclassical approximation and the structure of the eigenstates highly excited in bidimensional billiards and quantum maps. The results are applied to the determination of the chaotic effects in nuclear reactions. Additionally, it is started the study of the semiclassical properties of some circuits that can be applied to quantum computation.

Atomic Clusters.

Measurements of absolute inelastic cross-sections corresponding to collisions between electrons of low energy and sodium clusters suggest that the dominant process for the lower energies than the ionization energy, is the capture of the incident electron. That process would produce the temporary formation of a Na anion followed by some mechanism of energy dissipation. Among the probable processes of the anion creation it have been analyzed the inverse photoemission. Within this idea, it has been done theoretical quantum calculations that produce absolute cross-sections. It has been used a hamiltonian that include the interaction of the incident electron with the quantified field of the electromagnetic radiation. Through this interaction, the electron looses a discrete amount of energy and makes a transition from an state of the continuum to a bound state of the cluster, emitting a photon.

Numerical verification of Percival's conjecture in a quantum billiard

Gabriel Carlo, Eduardo Vergini and Alejandro J. Fendrik

In order to verify Percival's conjecture we study a planar billiard in its classical and quantum versions. We provide an evaluation of the nearest neighbour level spacing distribution for the Cassini oval billiard, taking into account relations with classical results. The statistical behaviour of integrable and ergodic systems have been extensively confirmed numerically, but that is not the case for the transition between these two extremes. Our system's classical dynamics undergoes a transition from integrability to chaos by varying a shape parameter. This feature allows us to investigate the spectral fluctuations, comparing numerical results with semiclassical predictions founded on Percival's conjecture. We obtain good *global* agreement with those predictions, in clear contrast with similar comparisons for other systems found in the literature. The structure of some eigenfunctions, displayed in the quantum Poincar\'e section, provide a clear explanation of the conjecture.

** Phys. Rev. E **57** (1998) 5397.*

Localized structures embedded in the eigenfunctions of chaotic Hamiltonian systems

E. Vergini and D.A. Wisniacki

We study quantum localization phenomena in chaotic systems with a parameter. The parametric motion of energy levels proceeds without crossing any other and the defined avoided crossings quantify the interaction between states. We propose the elimination of avoided crossings as the natural mechanism to uncover localized structures. We describe an efficient method for the elimination of avoided crossings in chaotic billiards and apply it to the stadium billiard. We find many scars of short periodic orbits revealing the skeleton on which quantum mechanics is built. Moreover, we have

observed strong interaction between similar localized structures.

** Phys. Rev. E **58** (1998) R5225.*

The influence of phase space localization in the quantum dynamics of a chaotic billiard

D.A. Wisniacki and E. Vergini

The quantum dynamics of a chaotic billiard with moving boundary is considered in this work. We found a perturbative expansion of the Hamiltonian corresponding to a planar billiard in powers of the shape parameter which enables long time evolution of the system. In particular, the dispersion of the energy is studied in the Bunimovich stadium billiard with oscilating boundary. The results showed that the distribution of energy spreads diffusively for the first oscillations of the boundary ($<\Delta E^2> = D\ t$).

We studied the diffusion contant *D* as a function of the velocity of the boundary and found differences with theoretical predictions. We showed numerical evidences that such differences are due to localization in phase space.

** Phys. Rev. E **59** (1999) 6579.*

Quantitative study of scars in the boundary section of the stadium billiard

Fernando P. Simonotti, Eduardo Vergini and Marcos Saraceno

We construct a semiclassically invariant function on the boundary of the billiard, taken as the Poincaré section in Birkhoff coordinates, based on periodic orbit information, as an ansatz for the normal derivative of the eigenfunction. Defining an appropriate scalar product on the section, we can compute the *scar intensity* of a given periodic orbit on an eigensate, as the overlap between the constructed function and the normal derivative on the section of the eigenstate. In this way, we are able to investigate how periodic orbits scar the spectrum and how a given eigenstate decompose into *scar functions.*

We use this scheme on the Bunimovich stadium.

** Phys. Rev. E **56** (1997) 3859.*

Boundary contributions to the semiclassical traces of the Baker's map

F. Toscano, R. O. Vallejos and M. Saraceno

We evaluate the leading asymptotic contributions to the traces of the quantum baker's map propagator. Besides the usual Gutzwiller periodic orbit contribution, we identify boundary paths giving rise to anomalous log(h) terms. Some examples of these anomalous terms are calculated both numerically and analytically.

** Nonlinearity **10** (1997) 965.*

Temperature antipairing effect over the energy weighted sum rule and the effective nuclear mass

E.C. Seva, H.M.Sofia and A.Tonina [1]

We study the temperature dependence of the sum rules using the discontinuity of the first derivative of the Matsubara Green's functions of a bilinear particle-hole operator. Particularly we study the behavior of the dipole particle-hole operator. We applied the calculation to ^{114}Sn, ^{138}Ba, ^{154}Gd and ^{170}Yb. It is found that the energy weighted sum rule for the dipole operator changes as a function of the temperature depending on the square of the gap. This fact is related to the antipairing effect of the temperature over the nuclear system.

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Quantization of multidimensional cat maps

A.M.F. Rivas[1]*, M. Saraceno and A.M. Ozorio de Almeida*[2]

In this work we study cat maps with many degrees of freedom. Classical cat maps are classified using the Cayley parametrization of symplectic matrices and the closely associated center and chord generating functions. Particular attention is dedicated to loxodromic and elliptic-hyperbolic behavior, which are new features of four-dimensional maps: we construct a map that is not Anosov, but is ergodic and mixing. The maps are then quantized using a Weyl representation on the torus and the general condition on the Floquet angles is derived for a particular map to be quantizable. The semiclassical approximation is exact, regardless of the dimensionality or of the nature of the fixed points. We single out the study of the Quantum Period Function (QPF), that is the period of the quantum map as a function of the finite Hilbert space dimension. It is found that the QPF is insensitive to the structural stability, though it depends on the ergodicity and on the existence of degenerated Lyapunov exponents for some power of the cat map.

** To be published in Nonlinearity*

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The construction of a quantum markov partition

Raúl O. Vallejos[1] and Marcos Saraceno

We present a method for constructing a quantum Markov partition. Its elements are obtained by quantizing the characteristic function of the classical rectangles. The result is a set of quantum operators which behave asymptotically as projectors over the classical rectangles except from edge and corner effects. We investigate their spectral properties and different methods of construction. The quantum partition is shown to induce a symbolic decomposition of the quantum evolution operator. In particular, an exact expression for the traces of the propagator is obtained having the same structure as Gutzwiller periodic orbit sum.

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Electron and photon collisions on potassium clusters

M.R. Spinella, M. Bernath, O. Dragún

A theoretical analysis of electron elastic collisions on K_{19} clusters was performed. We also evaluate the photoemission (electron detachment) and inverse photoemission (electron attachment) processes for low electron energies. We perform a quantum-mechanical calculation in the framework of the Local Density Approximation (LDA) to Density Functional Theory (DFT). The quasi-bound states presented in the elastic channel are also manifested in the other two processes. Thus, the corresponding cross sections, when studied as a function of the photon energies, are highly structured providing valuable theoretical information about the differences between the single particle energies below and above de Fermi level in the K_{19} cluster.

Temperature dependence and fragmentation of the particle-hole giant resonances

E.C. Seva and H. M.Sofia

We evaluate the spreading width of the Giant Multipole Resonances at finite temperature using the discontinuity in the second derivative of the Green's function of the vibrational boson, in the Matsubara's framework. Our method allows us to identify the processes that contribute to the spreading width in terms of the Feynman diagrammatic expansion of the full boson propagator. We have applied the calculation of the spreading width to the ^{208}Pb and the ^{90}Zr obtaining an increment of the spreading width with the temperature. We have not reached any saturation of the spreading width increment, at least up to the temperature of our calculation.

** Phys. Rev. C **56** (1997) 3107.*

How to scale the wave functions in a simple solvable model

M.C.Cambiaggio, L.M.Sanchez and G.G.Dussel

The scaling properties of the exact wave functions in the two-level pairing model are studied and a well-defined limit, when the number of pairs goes to infinity, is found. An approximate method for obtaining the scaled wave functions is discussed. Well-known methods for relating finite-difference equations with differential ones are used, together with a semiclassical expansion. The approximate results obtained agree well with the exact ones. A comparison with the time-dependent Hartree-Fock approach is also done.

*Phys. Rev. C **56** (1997) 2508*

Excitation of isovector modes in very neutron-reach nuclei via heavy-ion isoscalar probes

C. H. Dasso[1], H.M.Sofia, S. M. Lenzi[2], M. A. Nagarajan[3], A. Vitturi[4]

The existence of a neutron skin in neutron-rich nuclei is discussed in conexion with the excitation of isovector dipole and quadrupole giant modes via isoscalar nuclear probes. In the case of large neutron excess, important contributions are obtained from the nuclear excitation, which may even become predominant according to proper kinematical conditions. At variance with the usual situation encountered in inelastic processes, constructive interference can be found between nuclear and Coulomb contributions

** Nucl. Phys. A **627** (1997) 349.*

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Comparison between a thermal and a time-dependent mean-field description of a two level bosonic model

M.C.Cambiaggio, G.G.Dussel and A.M.Szyferman

The thermal mean-field (Hartree-Bose-Bogoliubov) approximation is applied to a simple bosonic model that is related to the phase transition

from spherical to deformed nuclei. Similarities and differences with the time-dependent approach are discussed, in particular the sensitivity of each method for the detection of the phase transition.

* *Phys. Rev. C* ***60*** *(1999) 443.*

Integrability of the pairing Hamiltonian

M.C.Cambiaggio, A.M.F.Rivas and M.Saraceno

We show that a many-body Hamiltonian that corresponds to a system of fermions interacting through a pairing force is an integrable problem, i.e. it has as many constants of the motion as degrees of freedom. At the classical level this implies that the time-dependent Hartree-Fock-Bogoliubov dynamics is integrable and at the quantum level that there are conserved operators of two-body character which reduce to the number operators when the pairing strength vanishes. We display these operators explicitly and study in detail the three-level example.

* *Nucl. Phys. A* ***624*** *(1997) 157.*

The pairing interaction and the Galileo invariance

G.G.Dussel [1,2]*, H.M.Sofia* [2] *and A.Tonina* [1]

The relation between Galileo invariance and the Energy Weighted Sum Rule for a mass dipole operator is discussed using a monopole pairing interaction. It is found that the energy weighted sum rule for the mass dipole operator change as much as 18% in medium and heavy nuclei.

* *Phys. Rev. C* ***56*** *(1997) 804.*

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