IC/79/2
INTERNAL REPORT
(Limited distribution)

International Atomic Energy Agency
and
United Nations Educational Scientific and Cultural Organization

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

FEW-BODY SYSTEM AND PARTICLE RESONANCES *

Mubarak Ahmad **
International Centre for Theoretical Physics, Trieste, Italy.

ABSTRACT

Techniques of few-body system in nuclear physics are exploited to analyse the spectrum of the Υ resonance and its family. Their relation to nuclear resonances are established so as to apply few-body dynamical techniques in the dynamical structure of particles carrying the truth quantum number.

MIRAMARE - TRIESTE
January 1979

* Paper presented at the 8th International Conference on Few-Body Systems and Nuclear Forces, Graz, Austria, 24-30 August 1978.

** Permanent address: Department of Physics, University of Kashmir, Srinagar, India.

After the recent discovery of Υ resonance [1] (upsilon meson) around 9.4 (GeV), it is now widely accepted that the Υ family is a bound state $t\bar{t}$ of a fifth quark, carrying the truth quantum number. In this note, we are concerned with some of the few-body aspects of this spectrum. The discovery of Υ resonances and the speculation of the fifth quark have given rise to a rich spectroscopy of elementary particles and has made SU(5) symmetry topical recently. [2]. We have given a new spectroscopy for these resonances incorporating the truth quantum number with charge $\frac{2}{3}$. [3] The mass spectra in GeV of this family of mesons and the corresponding new baryons carrying the truth quantum number that are identified in our scheme are as follows:

Mesons Υ = 9.44 (GeV), Υ' = 9.69 (GeV), Υ'' = 9.86 (GeV),

Υ''' = 10.05 (GeV), Υ^{o} = 10.37 (GeV) .

Baryons uut = 17.06 (GeV), sst = 17.20 (GeV), ctt = 17.23 (GeV)

dct = 17.0 (GeV), ttt = 17.46 (GeV) .

From the energy level diagram, it becomes evident that the level of the hadronic states increases as the content of the t quark increases, in the composite structure of the topomonium hadrons. This copes with the Eichten and Gottfried diagram [4]. The level diagrams of these truthful hadrons show remarkably the salient aspects of the typical nuclear physics level diagrams. The t quark is very heavy and the motion becomes non-relativistic. In this way this model contributes a great deal to our knowledge to relate such hadronic and nuclear physics spectroscopies.

The production of resonances and their properties in three and more particle systems appears to be a common feature in nuclear and particle physics. Resonances like the A_1 bump and spectators Δ seem to be the isobar content of the excited nuclear states. This then becomes pertinent with respect to the quark model description of hadrons. The quark model predicts two octets of vector mesons with $J^{PC} = 1^{++}$ and 1^{+-}, in which A and B mesons are accommodated. Further, the interaction of relativistic heavy ions has some of the following properties. The existence of many closely packed $J^{PC} = 1^{--}$ states around 9.4 GeV demands model states of excitations that are prevalent in nuclear states having the same spin and parity. The excitations of the great dipole resonance in light nuclei are described as the collective excitations of many particle-like hole states $J^P = 1^-$, differing only in shell model orbitals of the various states. Analogously, the states of the T family can be imagined as five-quark composite, dynamically paired as $(t\bar{q})$, where q's are SU(4) quarks. These states represent the exotic mesons. The exotic quarks and antiquarks $E\bar{E}$ now become eight-or six-dimensional representations to cope with the data.and the E mesons have a type of string structure [5]. The colour and quark confinement string models must become phenomenological in such situations [6] and resemble giant dipole resonant states. Hence the few-body techniques can also be aptly exploited for the dynamical calculations of these resonant mesons. The colour and quark confinement in a deformed MIT bag model for these resonances resemble the unified model of nuclear structure.

The hadronic decay of heavy quark Q and anti-quark $\bar{Q}$ vector mesons proceeds via the annihilation of the $Q\bar{Q}$ system into gluons, which materialize into SU(5) hadrons. The annihilation rate of $Q\bar{Q}$ into gluons calculated in the lowest-order quantum chromodynamic perturbation theory is an analogue of the Ore-Powell formula for orthopositronium decay, being studied in nuclear physics [7]. The three-body decay analogue, namely the three-gluon decay for these resonances via the three-gluon channel, becomes clear only in the case of hadrons containing heavy quarks such as T and ψ resonances, and this picture becomes clear for T particles. This may further improve if we proceed to hadrons containing still heavier quarks.

ACKNOWLEDGMENTS

The author would like to thank Professor Abdus Salam, the International Atomic Energy Agency and UNESCO for hospitality at the International Centre for Theoretical Physics, Trieste.

REFERENCES

1) S.W. Herb et al., Phys. Rev. Letters 39, 252 (1977).

2) W.K.H. Panofsky, Stanford Linear Accelerator Centre, SLAC-PUB-2025.

3) M. Ahmad et al., to be published.

4) E. Eichten and K.Gottfried, Phys. Letters 66B, 286 (1977).

5) R.C. Giles and S.-H.H.Tye, Phys. Letters 73B, 30 (1978).

6) Y.J. Ng and S.-H.H. Tye, Phys. Rev. D16, 2468 (1977).

7) A.O. Ore and J. Powell, Phys. Rev. 75, 1696 (1949).

CURRENT ICTP PREPRINTS AND INTERNAL REPORTS

IC/78/88 J.C. PATI and ABDUS SALAM: Signatures for axial chromodynamics.

IC/78/90 INT.REP.* F. HAMZA: Existence and uniqueness of solution of the third boundary value dynamic problem of infinite elastic homogeneous region.

IC/78/91 INT.REP.* F. HAMZA: Uniqueness and existence of solution of the generalized second principal dynamical problem.

IC/78/98 CAO-XUAN-CHUAN and H. VAN REGEMORTER: Analytical solution of a system of two coupled Schrödinger equations.

IC/78/99 M. QUIRÓS: Renormalization of the new trajectory in the unitarized conventional dual model.

IC/78/100 A. ADAMCZYK and R. RĄCZKA: New relativistic wave equations associated with indecomposable representations of the Poincaré group.

IC/78/101 R. RĄCZKA: On the existence of quantum field models in four-dimensional space-time.

IC/78/102 INT.REP.* C.V. SASTRY and D. MISRA: Mixing angles of the vector and pseudo-scalar meson isosinglets.

IC/78/103 INT.REP.* S.A. AFZAL and SHAMSHER ALI: A note on the Hall-Post theorem and α-cluster structure of nuclei.

IC/78/104 INT.REP.* SHAMSHER ALI and G. SCHIFFRER: Theoretical aspects of the non-local folding model and the Perey-Buck potential.

IC/78/105 INT.REP.* E. RECAMI and K. TAHIR SHAH: Multiply-connected space-time, black holes and tachyons.

IC/78/107 INT.REP.* R. MICNAS and L. KOWALEWSKI: Dyson equation for transverse Ising paramagnet.

IC/78/109 INT.REP.* L.F. ABD ELAL: A Galerkin algorithm for solving Cauchy-type singular integral equations.

IC/78/110 INT.REP.* H. BOGDANOVIC and M.S. GOPINATHAN: A canonical transformation of the Hamiltonians quadratic in co-ordinate and momentum operators.

IC/78/111 INT.REP.* M.A. ABOUZEID, A. RABIE and A.A. EL-SHEIKH: Single neutron transfer reactions between heavy ions: semiclassical treatment.

IC/78/112 INT.REP.* S.P. DE ALWIS: Chirality selection rules and the spontaneous breaking of SU(3) x SU(3).

IC/78/113 INT.REP.* M.Y.A. YOUSSEF: Short note on the mixed KdV and mKdV equation.

IC/78/114 INT.REP.* S.A. EL WAKIL and M.H. HAGGAG: Asymptotic solution to the reflected critical slab.

IC/78/115 INT.REP.* E.A. SAAD, M. SAWAN and S. SHEBL: Resonance integral in fuel with grain structure.

IC/78/116 L.SH. KHODJAEV: Basis of dynamical models of quantum theory localizable interactions - I: A model of exponential Lagrangians.

IC/78/117 INT.REP.* P. GARBACZEWSKI: Almost Fermi, Bose distributions of spin-1/2 approximation of Bose modes in quantum theory.

IC/78/118 H.B. GHASSIB: A generalized perturbation theory for dense Fermi systems.

IC/78/121 INT.REP.* N.H. MARCH and M.P. TOSI: Hydration of divalent ions in ice.

IC/78/122 INT.REP.* G. FURLAN and E. GAVA: Meron solutions in a non-abelian conformal invariant Higgs model.

IC/78/123 INT.REP.* J. SANTAMARINA: SU(4) Yang-Mills field solution.

IC/78/124 INT.REP.* H.B. GHASSIB and G. BASKARAN: A ^4He effective interaction for dilute solutions of ^4He in liquid ^3He at low temperatures.

IC/78/125 G. SENATORE, M. PARRINELLO and M.P. TOSI: Optical absorption of dilute solutions of metals in molten salts.

IC/78/128 A. OSMAN: Three-body model for stripping nuclear reactions.

IC/78/129 INT.REP.* I.A. ELTAYEB and M.H.A. HASSAN: On the non-linear evolution of sand dunes.

IC/78/130 INT.REP.* A.M. KHAN: Gamow-Teller decay of the 0.617 MeV 7^+ state in ^{42}Sc.

IC/78/132 INT.REP.* G. GIULIANI and E. TOSATTI: Longitudinal phonon spectrum of incommensurate one-dimensional charge-density-waves.

IC/78/133 P. BUDINI, P. FURLAN and R. RĄCZKA: Weyl and conformal covariant field theories.

IC/78/136 INT.REP.* Second Latin-American workshop on self-consistent theories of condensed matter - 9-20 October 1978 (Contributions).

IC/78/137 ABDUS SALAM: The electroweak force, grand unification and superunification.

IC/78/138 P. BUDINI, P. FURLAN and R. RĄCZKA: A possible geometrical origin of isotopic symmetry group in strong interactions.

IC/78/139 INT.REP.* J. TARSKI: Remarks on localizability and on quantized gauge fields.

IC/78/140 INT.REP.* CAO-XUAN-CHUAN: On the JWKB approximation in the case of a multi-component potential.

IC/78/141 INT.REP.* S.N. PANDEY: On conformal invariance of gravitational wave equations.

IC/78/142 INT.REP.* P. BUDINI, P. FURLAN and R. RĄCZKA: Possible origin of isotopic spin from extended conformal symmetry.

IC/78/143 J. NIEDERLE: The unusual algebras and their applications in particle physics.

---

* Internal Reports: Limited distribution.

THESE PREPRINTS ARE AVAILABLE FROM THE PUBLICATIONS OFFICE, ICTP, P.O. BOX [illegible]

IC/78/144 INT.REP.* L. BERTOCCHI and D. TRELEANI: K^0 regeneration in nuclei and the effect of the inelastic intermediate states.

IC/78/145 INT.REP.* J. LUKIERSKI: Graded orthosymplectic geometry and OSp(4;1)-invariant fermionic σ-models.

IC/78/146 J. LUKIERSKI: Field operator for unstable particle and complex mass description in local QFT.

IC/78/148 INT.REP.* A. QADIR: Field equations in twistors.

IC/78/149 I.I. DELCHEV, E.K. MARCHEV and I.J. PETKOV: A view on reactions of complete fusion.

IC/78/150 INT.REP.* T. SUZUKI: An anomaly-free regularization for axial-vector current.

IC/78/151 INT.REP.* M. ROVERE, R. MINIERO, M. PARRINELLO and M.P. TOSI: Gas-liquid transition in charged fluids.

IC/78/152 A.N. ANTONOV, V.A. NIKOLAEV and I.Z. PETKOV: Coherent fluctuations of nuclear density.

IC/78/153 INT.REP.* M.A. NAMAZIE: On an OSp(1,4) renormalizable theory of supergravity with higher derivatives.

IC/78/158 INT.REP.* V. ELIAS and S. RAJPOOT: Enhanced flavour charge in the integer quark charge model.

IC/78/160 INT.REP.* V. DE ALFARO, S. FUBINI and G. FURLAN: Gauge theory and strong gravity; the use of Weyl invariance.