Collective Motions in Nature

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Abstract

It is pointed out that the colletive motion plays the important role in the proper account of the dynamical nature of the earth. In order to perform this program it is nice to treat the kinematics of the dynamical motion in terms of the spherical coordinate system. The method should at least be known by geophysicists. However, it does not seem to be well discussed in the introductory text books of geology as far as the present author looked at them.

The idea was developed by the stimulation from a recent discovery on the physics of fundamental particles and fields on the one hand and the various diserstrous phenomena appeared in the newspapers as a result of the landslips in rainy season in Japan and those occuring in Mount Himaraja as an affect of the artificial destruction of nature on the other.

As an example of the collective effect we present the unpublished analysis for the spectroscopies of pion and charmonium families based on the U(6/2) dynamical supersymmetry proposed by the author. As an additional example of the group theoreeical approach we shall present the reult that the recently observed magnetic moment of Σ^--hyperon agrees with that predicted by the present author a few years before.

In Appendix the computer program used for the baryon mass formula is given, based on BASIC, for convenience.

1. Introduction

Grooptheoretically the collective motion may naturally be described by the one of the continuous Lie group U(6). Here, the number 6 arises from the number of degrees corresponding to the orbital motion with quantum numbers $L=0$ and $L=2$, viz., $\Sigma(2L+$

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1)=6.

In the relms of nuclear physics and particle-fields it appeared as U(6/4)[1] and U(6/2),[2] respectively. Here U(6/m) represents the group of the so-called supersymmetry which realizes the boson and fermion degree of freedoms in one and the same group. We shall not get into the detail of these groups and in stead borrow the ideas from them. Actually these groups are the subgroups of the Poincaré group which realizes locally the requirements of general relativity.[3] The theories of supersymmetry[4] and supergravity[5] are now popular for the high-energy theoretical physicists. In the category of the latter theory there is the model based on the ones by Kaluza[6] and Klein[7] which are proposed by the first author in order to unify the electromagnetism and general relativity and developed further by the latter. The extended theory of them plans to unify all the known fundamental interactions in nature.[8]

We shall mention only the scale of energy learnt from the study[2] of this theory and its extension to nature. In what follows we shall state the energy scales for particle, nuclear, atomic and earth physics in this introduction and then describe the approach in the spherical coordinate system in the next section. All the mathematical methods on the dynamical treatment of the earth science may be learnt from the appropriate text books on quantum mechanics or from the classical text books written by Rayleigh.[9] The interested scientists may find many more useful references by themselves so we shall not cite other useful references for that purpose except for some particular ones in later section.

The energy scale $1/a_h$ learnt from the bound states of quarks (antiquarks) and gluons are found to be

$$\left(\frac{1}{a_h}\right)^2 \simeq m\frac{2}{h} \simeq (\text{a few hundred MeV})^2 \tag{1.1}$$

in the relativistic notion.

The similar value in nuclear physics becomes

$$\frac{1}{m_{nucl}}\left(\frac{a_h}{a_{nucl}}\right)^2 m\frac{2}{h} \simeq (\text{a few ten keV}) \tag{1.2}$$

in the non-relativistic limit. Here m_{nucl} and a_{nucl} represent the mass and the radius of the particular nucleus, respectively. The numerical value is estimated for the mass number $A \simeq 200$.

If we come to the atomic world it becomes

$$\frac{1}{m_e}\left(\frac{a_h}{a_{atom}}\right)^2 m\frac{2}{h} \simeq (\text{a few eV}). \tag{1.3}$$

Here m_e and a_{atom} are the the mass of electron and atomic radius, respectively. Up to here we have used the so-called natural unit, viz., $\hbar = c = 1$.

In the same unit the energy scale for the matter may become

$$\frac{1}{m_{matter}} \left(\frac{a_h}{a_{matter}}\right)^2 m_h^2 \simeq \text{(a local gravitational energy)}. \quad (1.4)$$

Here m_{matter} and a_{matter} should be chosen appropriately. In such a choice one may find a energy scale suitable to discuss the dynamics of the landslips, earthquakes etc., at least qualitatively.

In the practical study one can estimate "a local gravitational energy" by making use of the Newtonian constant, the radius from the center of earth and the density of the mass at the point in which one is interested.

We have analysed already mass spectroscopy of the pion family once in HPICK-0115. However, the quantum state specification for the excited states was not appropriate there. The new result is much better than the one presented before. The charmonium study is completely new.

The prediction of the magnetic moments of baryons in group theoretical approach have been perfored by many authors. We have done it based on our predicted effective quark masses and SU(3) symmetry group, by taking into account the quanching effect for the identical bound quarks and the QCD enhancement phenomena.[10] In this prediction the magnetic moment of Σ^--hyperon was largely different from the theoretical result. The recently reported data[11] indicate the validity of our approach. These will be postponed to the final section.

In the next section we shall discuss the strategy to study various geology relevant problems in large.

2. Approach for the Collective Behaviour on Earth

It may be convenient to use the spherical coordinates in order to specify the local point in and on the earth. They are given by r_i, θ_i and ϕ_i.

In order to discuss the problem by Newtonian dynamics is is usual to assume that they are the function of time.[12] One can get the equations of motion at each point and a region sorrounding that point.

The region here may be specified conveniently in terms of manifold Δr_i, $\Delta \theta_i$, and $\Delta \phi_i$. One can cover all the desired region of the study by the sets of these quantities.

Perhaps the best (modern) approach to the problem can be done in terms of the classical field theory where the field variables are the function of continuous variables r, θ, ϕ and t (or x, y, z and t in the Cartesian coordinate system). Here t is the time variable.

We are quite sure that many diserstrous phenomena in nature on the earth certainly be cooked by the approach suggested. However, it should be done in combination with the real phenomena occuring in nature. This is far from the purpose of the present article.

What I can say is that Government should spend a certain amount of money in order to invite the fundamental physicists so as to promote the joint study with the geologists. Usually the good physicists are never interested in the global problem which does not contain the fundamental meanings.

The approach suggested seems to be too abstract for the untrained geologists. The work should also be done from various phases, so I shall quote some introductory texts from the fluiddynamics.[13,14] A partial answer on the subject may be found from these references.

Usually the geologists study the crystal structure appearing in minerals and artificial crystals intensively. Their group theoretical approach is confined, however, solely to the discrete groups: point and space groups. If they want to explore the dynamical problems they have to study the continuous groups.[15] Before becoming familiar with them the study of quantum mechanics through the standard texts will be very useful.

3. Mass Spectra of Pion and Charmonium Families in U(6/2) Dynamical SUSY and the Comment on Σ^--Magnetic Moment

The quadratic mass difference for hadrons in U(6/2) dynamical supersymmetry up to the quadratic Casimir invariants in subgroups may be given by

$$\text{(quadratic mass difference)} = b_4\,[\tau_1^{*2}(\tau_1^{*}+3)^2-\tau_1^{2}(\tau_1+3)^2]+\frac{1}{6}\,b\times$$

$$[\tau_1^{*}(\tau_1^{*}+3)-(\tau_1+3)]+c[J^*(J^*+1)-J(J+1)], \qquad (3.1)$$

where τ_1 and J are the one of the labels (τ_1, τ_2) specifying the irreducible representation of B_2 and that of A_1 embedded in the U(6/2), respectively, the starred quantities represent those for the excited states, b_4, b/6 and c are the numerical parameters to be determined experimentally.

The assignment of quantum numbers for two meson families are given in Table I. The result of the analysis is presented in Table II. The parameters thus determined are summarized in Table III.

In the pion family case the factor 5 improved in chi-square compared to the previous study even with the inclusion of the less well established states.[16] In spite of the large chi-square the fit obtained for the charmonium family seems to be reasonable. Here we included the the state[17] which is not tabulated in ref.[16]

In conclusion the U(6/2) dynamical SUSY gives the boson-fermion symmetry (supersymmetry) for the gluons and quarks at least in an approximate manner.

Table I. Classification of pion and Charmonium Families in U(6/2) Dynamical SUSY.

Pion Family			Chamonium Family		
τ_1	J^π	States	τ_1	J^π	States
0	1^-	$\rho(770)$	0	1^-	$J/\psi(3100)$
	0^-	$\pi(138)$		0^-	$\eta_c(2980)$
1	3^-	g(1690)	2	1^-	$\psi(3770)$
	2^-	$A_3(1680)$	3	1^-	$\psi(3685)$
2	3^-	$\rho(2250)$		0^-	$\eta_c'(3592)$
	2^-	$\pi(2100)$	4	1^-	$\psi(4030)$
	1^-	$\rho'(1250)$	5	1^-	$\psi(4160)$
3	1^-	$\rho'(1600)$	6	1^-	$\psi(4415)$
	0^-	$\pi(1300)$			
4	1^-	$\rho(2150)$			

Table II. Mass Spectra for Pion and Charmonium Families in U(6/2) Dynamical SUSY.

Pion Family				Charmonium Family			
τ_1	J^π	m^{theor} (in units of MeV)	m^{expt} (in units of MeV)	τ_1	J^π	m^{theor} (in units of MeV)	m^{expt} (in units of MeV)
0	1^-	759	769 ± 3	0	1^-	3097	3096.9 ± 0.1
	0^-	138	138		0^-	2981	2981 ± 6
1	3^-	1708	1691 ± 5	2	1^-	3451	3770 ± 3
	2^-	1115	1680 ± 30	3	1^-	3686	3686.0 ± 0.1
2	3^-	1785	2250 ± 200		0^-	3589	3592 ± 5
	2^-	1230	2100 ± 200	4	1^-	3932	4030 ± 5
	1^-	630	1264 ± 125	5	1^-	4170	4159 ± 20
3	1^-	1586	1600 ± 20	6	1^-	4380	4415 ± 6
	0^-	1399	1300 ± 100				
4	1^-	2827	2150 ± 200				

Table III. Parameters in Eq.(3.1) in units of $(\mathrm{MeV})^2$.

Family	b_4	$\frac{1}{6}b$	c	χ^2
Pion	15710.2	−175082	278836	306
Charmonium	−1235.76	244310	352496	10764

We shall only refer the result on the prediction made on the magnetic moment of Σ^--hyperon. Notice also that our result depends mainly on the magnetic moments of proton and neutron, since the original formula contains only two parameters except for the effective quark masses determined by spectroscopy of hadrons.

$$\mu_{\Sigma^-}\ (\text{theor}) = -0.963263\mu_N \tag{3.2}$$

will be comapred with the experimental value

$$\mu_{\Sigma^-}\ (\text{expt}) = -1.00 \pm 0.12\,\mu_N \text{ (weighted average).} \tag{3.3}$$

The old experimental value was $-1.41 \pm 0.25\,\mu_N$

I wanted to indicate some examples as a success of the group theoretical approach in this section.

The theoretical physicists are quite busy in pursuing the fundamental physics as exemplified by refs.[4,5] I shall stop the paper here and recommend to read the comments in Lack of Education in Japanese Universities, Studies in Humanities, Vol. 21 (1984) if one is interested.

References

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Appendix. BASIC Program for the Baryon Mass Formula

The program can be applied to meson case by an appropriate change.

The input data correspond to the earliest analysis. The lobic of the programming is so simple that no additional explanation will be necessary.

```
10 REM "BARYON"
20 REM "SUSY for BARYONS"
30 DIM T(20), J(20), M(20), DM(20), A(10, 10), C(10, 10), B(10), X(10)
40 MA = 939
50 MA = MA^2
60 MB = 1440
70 MB = MB^2
80 INPUT A
90 MO = A * MA + (1-A)* MB
100 K = 11
110 FOR I= 1 TO K
120 READ T(I), J(I), M(I), DM(I)
130 NEXT
140 FOR I = 1 TO K
150 M(I) = M(I)^2
160 DM(I) = 2 * SQR(M(I))* DM(I) + DM(I)^2
170 NEXT
180 A(1, 1) = 0
190 A(1, 2) = 0
200 A(1, 3) = 0
210 A(2, 2) = 0
220 A(2, 3) = 0
230 A(3, 3) = 0
240 B(1) = 0
250 B(2) = 0
260 B(3) = 0
270 FOR I = 1 TO K
280 F = T(I)*(T(I) + 3) -1.75
290 FF = (T(I)*(T(I) + 3))^2 - 3.0625
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300 G = J(I)*(J(I) + 1)-.75
310 A(1, 1) = A(1, 1) + FF^2/DM(I)^2
320 A(1, 2) = A(1, 2) + FF * F/DM( I )^2
330 A(1, 3) = A(1, 3) + FF * G/DM(I)^2
340 A(2, 2) = A(2, 2) + F^2/DM(I)^2
350 A(2, 3) = A(2, 3) + F * G/DM(I)^2
360 A(3, 3) = A(3, 3) + G^2/DM(I)^2
370 B(1) = B(1) + FF *(M(I) - MA)/DM(I)^2
380 B(2) =  B(2) + F *(M(I) - MA)/DM(I)^2
390 B(3) = B(3) + G *(M(I) - MA)/DM(I)^2
400 NEXT
410 A(2, 1) = A(1, 2)
420 A(3, 1) = A(1, 3)
430 A(3, 2) = A(2, 3)
440 N = 3
450 FOR I = 1 TO N
460 FOR J = 1 TO N
470 C(I,J) = A(I,J)/A(I,J)
480 NEXT J
490 C(I,I) = 0
500 NEXT I
510 FOR  I = 1 TO N
520 X(I) = 0
530 NEXT I
459 L = 1
550 FOR I = 1 TO N
560 D = 0
570 FOR J = 1 TO N
580 D =D + C(I,J) * X(J)
590 NEXT J
600 X(I( = (B(I)/A(I,I))-D
610 PRINT X(I);
620 NEXT I
630 PRINT L;
640 FOR I = 1 TO N
650 NEXT I
660 PRINT
```

```
670 IF L = 300 THEN 810
680 L = L+1
690 GOTO 550
700 DATA 1.5, 2.5, 1680, 10
710 DATA 1.5, 1.5, 1232, 2
720 DATA 2.5, 4.5, 2220, 75
730 DATA 2.5, 3.5, 1950, 25
740 DATA 2.5, 2.5, 1905, 15
750 DATA 2.5, 1.5, 1720, 55
760 DATA 2.5,. 5, 1710, 30
770 DATA 3.5, 5.5, 2420, 35
780 DATA 3.5, 3.5, 1990, 50
790 DATA 3.5, 1.5, 1920, 150
800 DATA 3.5,. 5, 1910, 50
810 KS = 0
820 FOR I = 1 TO K
830 F = T(I)*(T(I) + 3) - 1.75
840 FF = (T(I)*(T(I) + 3))^2 - 3.0625
850 G = J(I)*(J(I) + 1) - .75
860 M = FF * X(1) + F * X(2) + G * X(3) + MA
870 PRINT T(I); J(I); SQR(M); M; M(I); DM(I)
880 KS = KS + (M-M(I))^2/DM(I)^2
890 NEXT I
900 PRINT "CS ="KS; "A = "A
910 FOR I = 1 TO N
920 PRINT "X(I) = "X(I)
930 NEXT
```