Radiative decays of ground state light vector mesons with non relativistic and relativistic phase spaces

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Introduction

The experimental facilities such as BES, E835, CLEO, BaBar, Belle, CDF, DO, NA60 etc. are capable of discovering new hadrons, new production mechanisms, new decays and transitions and in general will be providing high precision data sample with higher confidence level. Hence the study of mass spectroscopy and decay rates of various mesons becomes significant. The radiative decay of pseudoscalar and vector mesons particularly has been advocated as one of the observables most suited to predict the nature of the mesons. There have been different studies on the decay of vector mesons, scalar mesons and axial vector mesons. Radiative decays of ρ, ω and ϕ mesons were studied in the SND experiment at the VEPP-2M e^+e^- collider[1-10].

In our previous works we had obtained the radiative transitions of light mesons using non relativistic phase space. In this paper the transition widths are studied both in case of non relativistic and relativistic phase spaces.

The allowed M1 transitions are essentially $^3S_1$ --> $^1S_0$ and $^1S_0$ --> $^3S_1$. The rate for transitions from a $^3S_1$ state to $^1S_0$ state is given by

$$\Gamma_{(n^3S_1 \to \gamma m^1S_0)} = \frac{4}{3m^2} e_q^2 \alpha k_0^3 \left| I_{mn} \right|^2 ,$$

where I_{mn} is the overlap integral for unit operator between the coordinate wave functions of the initial and the final meson states and m is the mass of the quark[11].

$$I_{mn} = \int_0^\infty r^2 R_{nS}(r) R_{mS}(r) dr$$

For transitions from $^1S_0$ state to $^3S_1$ state the following expression for the rate is used.

$$\Gamma_{(n^1S_0 \to \gamma m^3S_1)} = \frac{4}{m^2} e_q^2 \alpha k_0^3 \left| I_{mn} \right|^2$$

Results and discussions

We have calculated the M1 transition widths for light vector meson states in the long wavelength approximation. These transitions are reported in PDG [12]. In our calculations the experimental values of the meson masses have been used. Table I gives the calculated values of transiton widths for various light vector meson states in non relativistic phase space. Table II gives the calculated values of transition widths for various light vector meson states in relativistic phase space.

Conclusions

The main objective of the present work has been the study of radiative decays of light vector mesons within the framework of NRQM formalism using both non relativistic and relativistic phase spaces. In this work we have obtained radiative decay widths of light vector mesons using spectroscopic parameters from which we obtained the masses of vector and pseudoscalar mesons. The experimental data on radiative decay rates is understood theoretically in terms of a multipole expansion model. The quality of the calculated results reveal that the non relativistic phase space is not a correct prescription for light vector mesons. Comparison between the photon energy and the mass of the emitting meson reveals that the relativistic phase space is more suited which is seen in our model calculations.

Table I. Radiative decay widths of light vector mesons in non relativistic phase space (keV)

Transition	Expl. value	Calculated
$\rho^+ \to \pi^+\gamma$	67.82 ± 7.55	545.57
$\rho^0 \to \pi^0\gamma$	102.48 ± 25.69	556.03
$\rho^0 \to \eta\gamma$	36.18 ±13.57	71.62
$\omega \to \pi^0\gamma$	714.85 ± 42.74	5343.2
$\omega \to \eta\gamma$	5.47 ± 0.84	9.44
$\phi(1020) \to \eta\gamma$	55.82 ± 2.73	255.22
$\phi(1020) \to \eta'(958)\gamma$	0.53 ± 0.31	0.29
$K^*(892)^0 \to K^0\gamma$	116.15 ± 10.19	372.63
$K^*(892)^+ \to K^+\gamma$	50.29 ± 4.66	252.23

Table II. Radiative decay widths of light vector mesons in relativistic phase space (keV)

Transition	Expl. value	Calculated
$\rho^+ \to \pi^+\gamma$	67.82 ± 7.55	58.41
$\rho^0 \to \pi^0\gamma$	102.48 ± 25.69	58.88
$\rho^0 \to \eta\gamma$	36.18 ±13.57	33.67
$\omega \to \pi^0\gamma$	714.85 ± 42.74	549.53
$\omega \to \eta\gamma$	5.47 ± 0.84	4.30
$\phi(1020) \to \eta\gamma$	55.82 ± 2.73	74.30
$\phi(1020) \to \eta'(958)\gamma$	0.53 ± 0.31	0.25
$K^*(892)^0 \to K^0\gamma$	116.15 ± 10.19	115.17
$K^*(892)^+ \to K^+\gamma$	50.29 ± 4.66	72.58

References

[1] V. E. Markushin, Eur. Phys. J. A 8, 2000, 389.
[2] J. A. Oller, Nucl. Phys. A 727, 2003, 353.
[3] Yu. Kalashnikova, A. E. Kudryavtsev, A. V. Nefediev, J. Haidenbauer and C. Hanhart, Phys. Rev. C 73, 2006, 045203
[4] D. Black, M. Harada and J. Schechter, Phys. Rev. Lett. 88 2002 181603
[5] H. Nagahiro, L. Roca, E Oset and B.S. Zou, Phys. Rev. D 78, 2008, 014012.
[6] H. Nagahiro, L. Roca and E. Oset, Phys. Rev. D 77, 2008, 0340175.
[7] L. Roca, A. Hosaka and E. Oset, Phys. Lett. B 658, 2007, 17.
[8] Y. B. Dong, A. Faessler, T. Gutsche and V. E. Lyubovitskij, Phys. Rev. D 77 2008 094013
[9] A. Faessler, T. Gutsche, V. E. Lyubovitskij and Y. L. Ma, Phys. Rev. D 76 2007 114008
[10] Tumaikin G M, Proc. of the 10-th Int. Conf. on High Energy Particle Accelerators. Serpukhov, 1977, vol.1, 443.
[11] W. Kwong, and J. L. Rosner *Phys. Rev.* D 38, 1988, 279
[12] K Nakamura et. al. (Particle Data Group) J. Phys. G 37, 2010, 075021