Strange Mesons in Kaluza-Klein Picture

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Abstract

We have performed an analysis of experimental data on mass spectrum of the resonance states containing strange mesons and compared them with the calculated values provided by Kaluza-Klein scenario. In this note we present the results of this analysis.

In our previous papers [1, 2] we have presented the arguments in favour of that the Kaluza-Klein picture of the world has been observed in the experiments at very low energies where the nucleon-nucleon dynamics has been studied. In particular we have found that geniusly simple formula for KK excitations provided by Kaluza-Klein approach gives an excellent description for the mass spectrum of two-nucleon system. In articles [3, 4] we have presented additional arguments in favour of Kaluza and Klein picture of the world. In fact, we have shown that simple formula provided by Kaluza-Klein approach with the fundamental scale early calculated [1] gives an excellent description for the mass spectrum of two-pion and three-pion systems. Now, taking this line, we have performed an analysis of experimental data on mass spectrum of the resonance states containing strange mesons and compared them with the calculated values provided by Kaluza-Klein scenario. In this note we present the results of this analysis.

Let us start with the study of two-kaon system. As in the previous cases we build the Kaluza-Klein tower of KK excitations for two-kaon system by the formula

$$M_n^{K^1K^2} = \sqrt{m_{K^1}^2 + \frac{n^2}{R^2}} + \sqrt{m_{K^2}^2 + \frac{n^2}{R^2}}, \quad (n = 1, 2, 3, \ldots), \quad (1)$$

where $K^i(i = 0, +, -) = K^0, K^+, K^-$ and $R$ is the same fundamental scale calculated early from the analysis of nucleon-nucleon dynamics at low energies [1, 2]

$$\frac{1}{R} = 41.481 \text{ MeV} \quad \text{or} \quad R = 24.1 \text{ GeV}^{-1} = 4.75 \times 10^{-13} \text{ cm}. \quad (2)$$

Kaluza-Klein tower such built is shown in Table 1 where the comparison with experimentally observed mass spectrum of $\phi$-mesons is also presented.

Throughout we have used Review of Particle Physics [5] where the experimental data on mass spectrum of the resonance states have been extracted from. Some known experimental information is collected in separate tables: Table 2 – Table 7. We see from
Tables 1–7 that there is a quite remarkable correspondence of the calculated KK excitations for two-kaon system with the experimentally observed mass spectrum of the φ-mesons. However, there are many empty cells in Table 1 where we have not found the corresponding experimental data. Maybe such data exist but we don’t know these data. Anyway, we would gratefully thank for any experimental information in this respect.

We also built the Kaluza-Klein tower of KK excitations for the \( K\pi \)-system by the formula

\[
M_n^{K\pi} = \sqrt{m_K^2 + \frac{n^2}{R^2} + m_\pi^2 + \frac{n^2}{R^2}}, \quad (n = 1, 2, 3, \ldots),
\]

which is shown in Table 8 where the comparison with experimentally observed mass spectrum is also presented. Some known experimental information concerning the experimentally observed resonance states in \( K\pi \)-system is collected in separate tables: Table 9 – Table 16. Again we see from Tables 8–16 that there is a quite remarkable correspondence of the calculated KK excitations for \( K\pi \)-system with the experimentally observed mass spectrum of the resonance states in \( K\pi \)-system. Here, there are empty cells in Table 8 as well, where we have not found the corresponding experimental data.

Calculating the Kaluza-Klein tower of KK excitations for the \( K^2\pi \)-system by the formula

\[
M_n^{K^2\pi} = \sqrt{m_K^2 + \frac{n^2}{R^2} + 2m_\pi^2 + \frac{n^2}{R^2}}, \quad (n = 1, 2, 3, \ldots),
\]

is shown in Table 17 where the comparison with experimentally observed mass spectrum has been presented too. Some known experimental information concerning the experimentally observed resonance states in \( K\pi\pi \)-system is collected in separate tables: Table 18 – Table 20.

As in previous history we see from Tables 17–20 a quite remarkable correspondence of the calculated KK excitations for \( K\pi\pi \)-system with the masses of the resonance states in \( K\pi\pi \)-system where such resonance states are experimentally observed. Many empty cells in Table 17 indicate a wide field in experimental study of \( K\pi\pi \)-system.

Here we also present the results calculating the Kaluza-Klein tower of KK excitations for the \( K\rho \)-system by the formula

\[
M_n^{K\rho} = \sqrt{m_K^2 + \frac{n^2}{R^2} + m_\rho^2 + \frac{n^2}{R^2}}, \quad (n = 1, 2, 3, \ldots).
\]

These results are shown in Table 21 together with existing experimental data. As usual more detailed experimental information concerning the resonance states in \( K\rho \)-system is collected in separate tables: Table 22 – Table 28.

Finally, we built the Kaluza-Klein tower of KK excitations for the \( K\eta \)-system by the formula

\[
M_n^{K\eta} = \sqrt{m_K^2 + \frac{n^2}{R^2} + m_\eta^2 + \frac{n^2}{R^2}}, \quad (n = 1, 2, 3, \ldots).
\]

This is shown in Table 29. Here we have found only one experimental point (see Table 30) corresponding to \( M_{17}^{K\eta} \) – storey. That is why, it needs the further experimental study of \( K\eta \)-system.

From analysis performed we could once more emphasize a remarkable fact mentioned in our previous papers: the resonances with the different quantum numbers may occupy
one and the same storey in KK tower.\textsuperscript{1} This is a peculiarity of the systematics provided by Kaluza-Klein picture.

We have also established here a new remarkable feature of Kaluza-Klein picture which manifests itself in the existence of intersecting mass terms corresponding to the states of the hadronic systems with the different mesons content. We enumerate such intersecting mass terms below.

**Intersecting mass terms**

- \( M_3^{2K}(1018.24 - 1025.99) \cap M_9^{K\pi}(1015.93 - 1020.70) \neq \emptyset \)
- \( M_5^{2K}(1070.95 - 1078.32) \cap M_3^{K\eta}(1070.39 - 1074.26) \neq \emptyset \)
- \( M_7^{2K}(1145.78 - 1152.37) \cap M_{11}^{K\pi}(1148.09 - 1152.35) \neq \emptyset \)
- \( M_8^{2K}(1189.69 - 1196.33) \cap M_7^{K\eta}(1192.30 - 1195.74) \neq \emptyset \)
- \( M_9^{2K}(1237.89 - 1244.27) \cap M_8^{K\eta}(1234.89 - 1238.21) \neq \emptyset \)
- \( M_{10}^{2K}(1289.63 - 1295.76) \cap M_{13}^{K\pi}(1287.00 - 1290.83) \neq \emptyset \)
- \( M_{10}^{2K}(1289.63 - 1295.76) \cap M_5^{K\rho}(1288.42 - 1292.29) \neq \emptyset \)
- \( M_{17}^{2K}(1721.62 - 1726.22) \cap M_{11}^{K\rho}(1726.10 - 1728.70) \neq \emptyset \)
- \( M_{25}^{2K}(2297.08 - 2300.53) \cap M_{17}^{K2\pi}(22976.78 - 2300.83) \neq \emptyset \)
- \( M_{25}^{2K}(2297.08 - 2300.53) \cap M_{23}^{K\rho}(2299.82 - 2301.66) \neq \emptyset \)
- \( M_5^{5\pi}(782.93 - 789.16) \cap M_1^{K2\pi}(777.83 - 790.61) \neq \emptyset \)
- \( M_8^{K\pi}(953.10 - 958.17) \cap M_4^{K2\pi}(948.60 - 958.24) \neq \emptyset \)
- \( M_{13}^{K\pi}(1216.82 - 1220.86) \cap M_1^{K2\pi}(1213.15 - 1220.53) \neq \emptyset \)
- \( M_{13}^{K\pi}(1287.00 - 1290.83) \cap M_3^{K\rho}(1288.42 - 1292.29) \neq \emptyset \)
- \( M_{14}^{K\pi}(1358.43 - 1362.08) \cap M_6^{K\rho}(1361.43 - 1365.00) \neq \emptyset \)
- \( M_{15}^{K\pi}(1430.97 - 1434.44) \cap M_8^{K\rho}(1432.67 - 1435.99) \neq \emptyset \)
- \( M_{22}^{K\pi}(1960.08 - 1962.67) \cap M_{20}^{K\eta}(1959.29 - 1961.34) \neq \emptyset \)
- \( M_{29}^{K\pi}(2510.82 - 2512.86) \cap M_{26}^{K\rho}(2510.90 - 2512.57) \neq \emptyset \)
- \( M_6^{K2\pi}(1119.13 - 1127.14) \cap M_5^{K\eta}(1120.76 - 1124.44) \neq \emptyset \)
- \( M_8^{K2\pi}(1311.35 - 1318.18) \cap M_4^{K\rho}(1307.81 - 1311.59) \neq \emptyset \)
- \( M_{10}^{K2\pi}(1517.25 - 1523.21) \cap M_{10}^{K\rho}(1518.82 - 1521.89) \neq \emptyset \)
- \( M_{11}^{K2\pi}(1623.93 - 1629.51) \cap M_{15}^{K\eta}(1622.94 - 1625.43) \neq \emptyset \)
- \( M_{13}^{K2\pi}(1842.89 - 1847.86) \cap M_{16}^{K\eta}(1843.20 - 1845.59) \neq \emptyset \)

\textsuperscript{1}Similar (“mass-band”) structures were empirically observed early in Ref. [6]. I thank D. Akers for drawing my attention to this article.
\[ M_{17}^{K_2\pi}(2296.78 - 2300.83) \cap M_{23}^{K\pi}(2299.82 - 2301.66) \neq \emptyset \]

Of course, it would be very desirable to state new experiments to search new states corresponding to the empty cells in Tables 1,8,17,21,29. These Tables may serve as a guide for the physicists-experimenters. We believe that this is a quite promising subject of the investigations in particle and nuclear physics.

References

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Table 1: Kaluza-Klein tower of KK excitations in $KK$-system and experimental data.

| n  | $M_n^{2K_n^0}$ MeV | $M_n^{K^0K^+}$ MeV | $M_n^{2K^+}$ MeV | $M_{exp}^{2K}$ MeV |
|----|--------------------|--------------------|------------------|-------------------|
| 1  | 998.80             | 994.81             | 990.83           |                   |
| 2  | 1009.08            | 1005.14            | 1001.20          |                   |
| 3  | 1025.99            | 1022.11            | 1018.24          | 1019.417±0.014    |
| 4  | 1049.21            | 1045.42            | 1041.63          |                   |
| 5  | 1078.32            | 1074.64            | 1070.95          |                   |
| 6  | 1112.87            | 1109.30            | 1105.73          |                   |
| 7  | 1152.37            | 1148.93            | 1145.48          |                   |
| 8  | 1196.33            | 1193.01            | 1189.69          |                   |
| 9  | 1244.27            | 1241.08            | 1237.89          |                   |
| 10 | 1295.76            | 1292.69            | 1289.63          |                   |
| 11 | 1350.38            | 1347.44            | 1344.50          | 1346 - i249       |
| 12 | 1407.77            | 1404.96            | 1402.14          |                   |
| 13 | 1467.62            | 1464.91            | 1462.21          | 1463 ± 9          |
| 14 | 1529.62            | 1527.02            | 1524.43          |                   |
| 15 | 1593.53            | 1591.04            | 1588.55          |                   |
| 16 | 1659.13            | 1656.74            | 1654.34          | 1655 ± 17         |
| 17 | 1726.22            | 1723.92            | 1721.62          |                   |
| 18 | 1794.64            | 1792.43            | 1790.22          |                   |
| 19 | 1864.24            | 1862.11            | 1859.99          | 1864.1 ± 1.0      |
| 20 | 1934.89            | 1932.85            | 1930.80          |                   |
| 21 | 2006.49            | 2004.52            | 2002.54          | 2006.7 ± 0.5      |
| 22 | 2078.93            | 2077.03            | 2075.12          |                   |
| 23 | 2152.14            | 2150.30            | 2148.45          |                   |
| 24 | 2226.02            | 2224.24            | 2222.46          |                   |
| 25 | 2300.53            | 2298.81            | 2297.08          |                   |
| 26 | 2375.60            | 2373.93            | 2372.26          |                   |
| 27 | 2451.17            | 2449.56            | 2447.94          |                   |
| 28 | 2527.21            | 2525.64            | 2524.08          |                   |
| 29 | 2603.67            | 2602.15            | 2600.63          |                   |
| 30 | 2680.52            | 2679.04            | 2677.57          |                   |
Table 2: $M_3^{2K}(1018 – 1023)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $\phi(0^- 1^{--})$ | $1019.417\pm 0.014$ | $4.458\pm 0.032$ | AVERAGE | PDG 00 |

Table 3: $M_{11}^{2K}(1345 – 1350)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $f_0(0^+ 0^{++})$ | $1346 - i249$ | $118^{+123}_{-16}$ | $\pi\pi \rightarrow \pi\pi, KK$ | RVUE 95 |

Table 4: $M_{13}^{2K}(1462 – 1468)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $f_0(0^+ 0^{++})$ | $1463\pm 9$ | $118^{+123}_{-16}$ | $\pi^- p \rightarrow 2K^0 n$ | MPS 82 |

Table 5: $M_{16}^{2K}(1654 – 1659)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $\phi(0^- 1^{--})$ & $1657 \pm 27$ & $146 \pm 55$ & $e^+ e^- \rightarrow K^0 K^\pm \pi^\mp$ & DM2 91 |
| & $1655 \pm 17$ & $207 \pm 45$ & $e^+ e^- \rightarrow K^+ K^-$ & DM2 88 |
| & $1681 \pm 8$ & $150 \pm 50$ & AVERAGE & PDG 00 |

Table 6: $M_{19}^{2K}(1860 – 1864)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $D^0(0^-)$ | $1864.1 \pm 1.0$ | $87_{-23}$ | AVERAGE | PDG 00 |

Table 7: $M_{21}^{2K}(2003 – 2006)$ -Storey.

| $R(I^G J^{PC})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------------|----------|----------------|----------|--------|
| $D^*(0^-)$ | $2006.7 \pm 0.5$ | $< 2.1$ | AVERAGE | PDG 00 |
Table 8: Kaluza-Klein tower of KK excitations in $K\pi$-system and experimental data.

| n | $M_n^{K^0\pi^0}$ MeV | $M_n^{K^0\pi^\pm}$ MeV | $M_n^{K^+\pi^0}$ MeV | $M_n^{K^+\pi^\pm}$ MeV | $M_{exp}^{K\pi}$ MeV |
|---|------------------|------------------|------------------|------------------|------------------|
| 1 | 640.60           | 645.00           | 636.62           | 641.02           |                  |
| 2 | 662.97           | 666.91           | 659.03           | 662.97           |                  |
| 3 | 696.58           | 699.99           | 692.71           | 696.11           |                  |
| 4 | 738.50           | 741.42           | 734.71           | 737.63           |                  |
| 5 | 786.62           | 789.16           | 782.93           | 785.47           |                  |
| 6 | 839.57           | 841.79           | 836.00           | 838.22           |                  |
| 7 | 896.39           | 898.36           | 892.95           | 894.91           | $K^*(892)$       |
| 8 | 956.42           | 958.17           | 953.10           | 954.85           |                  |
| 9 | 1019.12          | 1020.70          | 1015.93          | 1017.51          |                  |
| 10| 1084.10          | 1085.54          | 1081.03          | 1082.48          |                  |
| 11| 1151.03          | 1152.35          | 1148.09          | 1149.41          |                  |
| 12| 1219.64          | 1220.86          | 1216.82          | 1218.04          |                  |
| 13| 1289.70          | 1290.83          | 1287.00          | 1288.13          |                  |
| 14| 1361.03          | 1362.08          | 1358.43          | 1359.48          |                  |
| 15| 1433.45          | 1434.44          | 1430.97          | 1431.95          | $K^{*}_{0,2}(1430)$ |
| 16| 1506.85          | 1507.78          | 1504.46          | 1505.39          |                  |
| 17| 1581.09          | 1581.97          | 1578.79          | 1579.67          | $K_2(1580)$     |
| 18| 1656.08          | 1656.91          | 1653.87          | 1654.70          | $K^*(1680)$     |
| 19| 1731.74          | 1732.53          | 1729.61          | 1730.40          | $K^{*}_3(1780)$ |
| 20| 1807.98          | 1808.73          | 1805.93          | 1806.68          |                  |
| 21| 1884.75          | 1885.46          | 1882.77          | 1883.49          |                  |
| 22| 1961.98          | 1962.67          | 1960.08          | 1960.76          | $K_{0}^{*}(1950)$ |
| 23| 2039.64          | 2040.29          | 2037.80          | 2038.45          | $K_{4}^{*}(2045)$ |
| 24| 2117.67          | 2118.30          | 2115.89          | 2116.52          |                  |
| 25| 2196.04          | 2196.65          | 2194.32          | 2194.92          |                  |
| 26| 2274.72          | 2275.30          | 2273.06          | 2273.64          |                  |
| 27| 2353.68          | 2354.24          | 2352.07          | 2352.63          | $K_{5}^{*}(2380)$ |
| 28| 2432.90          | 2433.44          | 2431.33          | 2431.87          |                  |
| 29| 2512.34          | 2512.86          | 2510.82          | 2511.34          |                  |
| 30| 2592.00          | 2592.50          | 2590.52          | 2591.02          |                  |
Table 9: $M_{17}^{K\pi}(893 - 898)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K^*(\frac{3}{2}^-)$ | 896.1 ± 0.27 | 50.7 ± 0.6 | AVERAGE | PDG 00 |

Table 10: $M_{15}^{K\pi}(1431 - 1434)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K^*(\frac{1}{2}^0)$ | 1436 ± 8 | 196 ± 45 | $pp \rightarrow pfp_pK^+K^-\pi^+\pi^-$ | OMEG 98 |
| 1415 ± 25 | 330 ± 50 | $K^-p \rightarrow K^-\pi^+n$ | RVUE 97 |
| $\sim 1430$ | $\sim 200$ | $K^-p \rightarrow K^0\pi^-p$ | HBC 84 |
| $K^*(\frac{1}{2}^+)$ | 1431.2 ± 1.8 ± 0.7 | 116.5 ± 3.6 ± 1.7 | $K^-p \rightarrow K^-\pi^+n$ | LASS 88 |
| 1432.4 ± 1.3 | 109 ± 5 ± 1.7 | AVERAGE | PDG 00 |

Table 11: $M_{17}^{K\pi}(1578 - 1582)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K_0^*(\frac{1}{2}^-)$ | $\sim 1580$ | $\sim 110$ | $K^-p$ | AACH3 79 |

Table 12: $M_{18}^{K\pi}(1654 - 1657)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K^*(\frac{1}{2}^-)$ | 1677±10±32 | 205±16±34 | $K^-p \rightarrow K^-\pi^+n$ | LASS 88 |
| $\sim 1650$ | 250-300 | $K^+p \rightarrow K^+\pi^+n$ | ASPK 78 |

Table 13: $M_{19}^{K\pi}(1730 - 1733)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K_1^*(\frac{1}{2}^-)$ | 1740±14±15 | 171±42±20 | $K^-p \rightarrow K^-\pi^-n$ | LASS 87 |
| 1720±10±15 | 187±31±20 | $K^-p \rightarrow K^0\pi^-p$ | LASS 89 |

Table 14: $M_{22}^{K\pi}(1960 - 1963)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K_0^*(\frac{1}{2}^0)$ | 1945±10±20 | 201±34±79 | $K^-p \rightarrow K^-\pi^+n$ | LASS 88 |

Table 15: $M_{23}^{K\pi}(2038 - 2040)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K_1^*(\frac{1}{2}^4^+)$ | 2039 ± 10 | 189 ± 35 | $K^+p \rightarrow K^0\pi^+p$ | SPEC 82 |
| 2062±14±13 | 221±48±27 | $K^-p \rightarrow K^-\pi^+n$ | LASS 86 |
| 2045 ± 9 | 198 ± 30 | AVERAGE | PDG 00 |

Table 16: $M_{27}^{K\pi}(2352 - 2354)$–Storey.

| $R(IJ')$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|-----------|---------|
| $K_5^*(\frac{1}{2}^5^-)$ | 2382±14±19 | 178±37±32 | $K^-p \rightarrow K^-\pi^+n$ | LASS 86 |
Table 17: Kaluza-Klein tower of KK excitations in $K2\pi$-system and experimental data.

| n  | $M_{n}^{02\pi^{0}}$ MeV | $M_{n}^{2\pi^{0}}$ MeV | $M_{n}^{K^{+2\pi^{-}}}$ MeV | $M_{n}^{K^{+2\pi^{+}}}$ MeV | $M_{exp}^{K^{2\pi}}$ MeV |
|----|---------------------------|------------------------|-----------------------------|-----------------------------|-------------------------|
| 1  | 781.81                    | 790.61                 | 777.83                      | 786.62                      | 790.61                  |
| 2  | 821.41                    | 829.27                 | 817.47                      | 825.33                      | 821.41                  |
| 3  | 880.17                    | 886.98                 | 876.30                      | 883.10                      | 880.17                  |
| 4  | 952.39                    | 958.24                 | 948.60                      | 954.45                      | 952.39                  |
| 5  | 1034.08                   | 1039.15                | 1030.39                     | 1035.46                     | 1034.08                 |
| 6  | 1122.70                   | 1127.14                | 1119.13                     | 1123.57                     | 1122.70                 |
| 7  | 1216.60                   | 1220.53                | 1213.15                     | 1217.08                     | 1216.60                 |
| 8  | 1314.67                   | 1318.18                | 1311.35                     | 1314.86                     | 1314.67                 |
| 9  | 1416.10                   | 1419.27                | 1412.91                     | 1416.08                     | 1416.10                 |
| 10 | 1520.32                   | 1523.21                | 1517.25                     | 1520.14                     | 1520.32                 |
| 11 | 1626.87                   | 1629.51                | 1623.93                     | 1626.57 1629 ± 7            | 1626.87                 |
| 12 | 1735.39                   | 1737.83                | 1732.57                     | 1735.01 1730 ± 20           | 1735.39                 |
| 13 | 1845.59                   | 1847.86                | 1842.89                     | 1845.15                     | 1845.59                 |
| 14 | 1957.24                   | 1959.36                | 1954.65                     | 1956.76                     | 1957.24                 |
| 15 | 2070.14                   | 2072.12                | 2067.66                     | 2069.63                     | 2070.14                 |
| 16 | 2184.13                   | 2186.00                | 2181.74                     | 2183.60                     | 2184.13                 |
| 17 | 2299.07                   | 2300.83                | 2296.78                     | 2298.53                     | 2299.07                 |
| 18 | 2414.85                   | 2416.51                | 2412.64                     | 2414.30                     | 2414.85                 |
| 19 | 2531.36                   | 2532.93                | 2529.23                     | 2530.81                     | 2531.36                 |
| 20 | 2648.51                   | 2650.01                | 2646.46                     | 2647.96                     | 2648.51                 |
| 21 | 2766.25                   | 2767.68                | 2764.27                     | 2765.70                     | 2766.25                 |
| 22 | 2884.50                   | 2885.86                | 2882.59                     | 2883.96                     | 2884.50                 |
| 23 | 3003.21                   | 3004.51                | 3001.36                     | 3002.67                     | 3003.21                 |
| 24 | 3122.33                   | 3123.58                | 3120.55                     | 3121.80                     | 3122.33                 |
| 25 | 3241.82                   | 3243.03                | 3240.10                     | 3241.30                     | 3241.82                 |
| 26 | 3361.65                   | 3362.81                | 3359.98                     | 3361.14                     | 3361.65                 |
| 27 | 3481.78                   | 3482.90                | 3480.16                     | 3481.28                     | 3481.78                 |
| 28 | 3602.19                   | 3603.27                | 3600.62                     | 3601.70                     | 3602.19                 |
| 29 | 3722.85                   | 3723.89                | 3721.32                     | 3722.37                     | 3722.85                 |
| 30 | 3843.73                   | 3844.74                | 3842.25                     | 3843.26                     | 3843.73                 |
Table 18: $M_{11}^{K^2\pi}(1624 - 1630)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|-----------|----------------|----------|---------|
| $K(\frac{1}{2}^+)$ | 1629 ± 7 | $16^{+19}_{-16}$ | $\pi^- p \rightarrow K_S^0 \pi^+ \pi^-$ | BC 98 |

Table 19: $M_{12}^{K^2\pi}(1733 - 1738)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|-----------|----------------|----------|---------|
| $K_2(\frac{1}{2}^-)$ | 1730 ± 20, 1740, 1745 ± 20, 1765 ± 40 | 210 ± 30, 130, 100 ± 50, 90 ± 70 | $K^+ d$, $K^- d \rightarrow K 2\pi d$, $K^- p$, $K^+ p \rightarrow K 2\pi N$ | DBC 72, DBC 71, HBC 70, HBC 71 |

Table 20: $M_{13}^{K^2\pi}(1843 - 1848)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|-----------|----------------|----------|---------|
| $K_1(\frac{1}{2}^+)$ | $\sim 1840$ | $\sim 250$ | $K^- p \rightarrow 3K p$ | OMEG 83 |
| $K_2(\frac{1}{2}^-)$ | $\sim 1840$ | $\sim 230$ | $K^- p \rightarrow K^- 2\pi p$ | CNTR 81 |
| $K_2(\frac{1}{2}^-)$ | $\sim 1800$ | $\sim 250$ | $K^- p \rightarrow K^- 2\pi p$ | CNTR 81 |
Table 21: Kaluza-Klein tower of KK excitations in $K\rho$-system and experimental data.

| n | $M_n^{K^+\rho}$ MeV | $M_n^{K^0\rho}$ MeV | $M_{\exp}^{K\rho}$ MeV |
|---|-----------------|-----------------|-----------------|
| 1 | 1269.82         | 1265.83         |                 |
| 2 | 1278.30         | 1274.36         | 1273 ± 7        |
| 3 | 1292.29         | 1288.42         |                 |
| 4 | 1311.59         | 1307.81         |                 |
| 5 | 1335.93         | 1332.24         |                 |
| 6 | 1365.00         | 1361.43         |                 |
| 7 | 1398.46         | 1395.01         | 1402 ± 7        |
| 8 | 1435.99         | 1432.67         | 1414 ± 15       |
| 9 | 1477.24         | 1474.05         | ∼ 1460          |
| 10| 1521.89         | 1518.82         |                 |
| 11| 1569.63         | 1566.69         |                 |
| 12| 1620.19         | 1617.37         |                 |
| 13| 1673.29         | 1670.58         |                 |
| 14| 1728.70         | 1726.10         | 1717 ± 27       |
| 15| 1786.20         | 1783.71         | 1776 ± 7        |
| 16| 1845.59         | 1843.20         |                 |
| 17| 1906.71         | 1904.41         |                 |
| 18| 1969.39         | 1967.18         | 1973 ± 8 ± 25   |
| 19| 2033.48         | 2031.35         |                 |
| 20| 2098.86         | 2096.81         |                 |
| 21| 2165.42         | 2163.44         |                 |
| 22| 2233.05         | 2231.14         |                 |
| 23| 2301.66         | 2299.82         |                 |
| 24| 2371.16         | 2369.38         |                 |
| 25| 2441.49         | 2439.76         |                 |
| 26| 2512.57         | 2510.90         |                 |
| 27| 2584.34         | 2582.72         |                 |
| 28| 2656.75         | 2655.18         |                 |
| 29| 2729.75         | 2728.22         |                 |
| 30| 2803.29         | 2801.81         |                 |
Table 22: $M_2^{K\rho}(1274 - 1278)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K_1(\frac{3}{2}^1+)$ | 1275 ± 10  | 75 ± 15        | $K^-p \to \Xi(K\pi\pi)^+$ | HBC 78  |
|           | 1273 ± 7   | 90 ± 20        | AVERAGE  | PDG 00  |

Table 23: $M_7^{K\rho}(1395 - 1398)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K_1(\frac{3}{2}^1+)$ | 1392 ± 18  | 276 ± 65       | $K^-p \to K^0\pi^+\pi^-n$ | HBC 82  |
|           | 1402 ± 7   | 174 ± 13       | AVERAGE  | PDG 00  |

Table 24: $M_8^{K\rho}(1433 - 1436)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K^*(\frac{1}{2}^1-)$ | 1420±7±10  | 240±18±12      | $K^-p \to K^0\pi^+\pi^-n$ | LASS 87 |
|           | 1414 ± 15  | 232 ± 21       | AVERAGE  | PDG 00  |

Table 25: $M_9^{K\rho}(1474 - 1477)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K(\frac{1}{2}^0-)$ | ~ 1460    | ~ 260          | $K^-p \to K^-2\pi p$ | CNTR 81 |

Table 26: $M_{14}^{K\rho}(1726 - 1729)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K^*(\frac{1}{2}^1-)$ | 1735±10±20 | 423±18±30      | $K^-p \to K^0\pi^+\pi^-n$ | LASS 87 |
|           | 1717 ± 27  | 322 ± 110      | AVERAGE  | PDG 00  |

Table 27: $M_{15}^{K\rho}(1784 - 1786)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K^*_3(\frac{1}{2}^3-)$ | 1776 ± 7   | 159 ± 21       | AVERAGE  | PDG 00  |

Table 28: $M_{18}^{K\rho}(1967 - 1969)$–Storey.

| $R(IJ^P)$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction | Collab. |
|-----------|------------|----------------|----------|---------|
| $K^*_3(\frac{3}{2}^2-)$ | 1973±8±25  | 373±33±60      | AVERAGE  | PDG 00  |
Table 29: Kaluza-Klein tower of KK excitations in $K\eta$-system and experimental data.

| n | $M_{n\eta}^{KK\eta}$ MeV | $M_{n\eta}^{KK+\eta}$ MeV | $M_{exp}^{KK\eta}$ MeV |
|---|---------------------------|---------------------------|-------------------------|
| 1 | 1048.27                   | 1044.29                   |                         |
| 2 | 1058.09                   | 1054.15                   |                         |
| 3 | 1074.26                   | 1070.39                   |                         |
| 4 | 1096.50                   | 1092.71                   |                         |
| 5 | 1124.44                   | 1120.76                   |                         |
| 6 | 1157.67                   | 1154.10                   |                         |
| 7 | 1195.74                   | 1192.30                   |                         |
| 8 | 1238.21                   | 1234.89                   |                         |
| 9 | 1284.64                   | 1281.45                   |                         |
| 10| 1334.61                   | 1331.55                   |                         |
| 11| 1387.75                   | 1384.81                   |                         |
| 12| 1443.70                   | 1440.88                   |                         |
| 13| 1502.14                   | 1499.44                   |                         |
| 14| 1562.80                   | 1560.21                   |                         |
| 15| 1625.43                   | 1622.94                   |                         |
| 16| 1689.82                   | 1687.43                   |                         |
| 17| 1755.76                   | 1753.46                   | 1749 ± 10               |
| 18| 1823.08                   | 1820.88                   |                         |
| 19| 1891.65                   | 1889.53                   |                         |
| 20| 1961.34                   | 1959.29                   |                         |
| 21| 2032.01                   | 2030.04                   |                         |
| 22| 2103.59                   | 2101.68                   |                         |
| 23| 2175.97                   | 2174.13                   |                         |
| 24| 2249.08                   | 2247.30                   |                         |
| 25| 2322.86                   | 2321.13                   |                         |
| 26| 2397.23                   | 2395.56                   |                         |
| 27| 2472.15                   | 2470.53                   |                         |
| 28| 2547.57                   | 2546.00                   |                         |
| 29| 2623.44                   | 2621.92                   |                         |
| 30| 2699.73                   | 2698.25                   |                         |
Table 30: $M_{17}^{K\eta}(1753 - 1756)$–Storey.

| $R(J^{P})$ | $M_R$ MeV | $\Gamma_R$ MeV | Reaction       | Collab.   |
|------------|-----------|----------------|----------------|-----------|
| $K_3^*(\frac{1}{2}^-)$ | $1749 \pm 10$ | $193^{+51}_{-37}$ | $K^- p \rightarrow K^- \eta p$ | LASS 88   |