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# The puzzle of the A2 meson

The A2 may be two distinct but similar particles or a single object of an entirely new type. Either way, it has experimentalists arguing and theorists confused.

Peter Schübelin

Particles in high-energy physics have become so numerous that a new "resonance," as a short-lived unstable particle is called, must do something unusual to attract attention. The A2 meson, an otherwise ordinary resonance, stands out from the crowd by exhibiting a peculiar structure in its mass spectrum. Instead of the single peak of a normal resonance, the A2 has two closely spaced peaks with the separation between the peaks roughly equal to their width. This double peak implies that the A2 is really two particles with nearly the same mass, or perhaps a single object of an entirely new type, a double resonance or "dipole."

The very existence of the splitting of the A2 has been a topic of controversy for five years. Now, with the splitting all but certain, the question remains: What does this structure imply for the rest of high-energy physics? The most recent work indicates that the splitting is independent of how the A2 is produced and how it decays; furthermore both halves appear to have the same intrinsic quantum numbers. If splitting is found in the other members of the A2's SU(3) nonet, it means that we have found a fundamental feature in particle physics that could require the introduction of a new quantum number.

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## Resonances

Some background would be helpful before we discuss the experimental work that established these idiosyncrasies of the A2. A particle resonance may be viewed as a temporary "composite" of other particles—which themselves may be unstable—that decays by strong interactions. Although they are sometimes described as "bound" states, resonances exist as distinct entities for only about $10^{-23}$ sec. They fall into two classes: baryon and boson resonances.

Baryon resonances, the earliest to be discovered, are nucleon-like structures. The most familiar is the nucleon isobar N*(1238), also denoted $N^*_{33}$ and $\Delta$. A long series of baryon resonances has been discovered, mostly in experiments of the type

$$m_1 + B_1 \rightarrow X \rightarrow m_2 + B_2$$

where the m's are mesons (typically pions) and the B's are baryons (typically protons), and X denotes the baryon resonance. This type of experiment is called a "formation experiment," because the two initial particles actually combine to "form" the resonance. Resonances show up as bumps in the scattering cross section, or as marked changes in the angular distribution of $m_2$ and $B_2$, when the bombarding energy goes through the value corresponding to the mass of the resonance.

Boson resonances are composites of two or more mesons and may include baryon–antibaryon pairs as well. The boson resonances can not arise in formation experiments with a meson beam and a baryon target because the total baryon number of a boson resonance must be zero. They could be observed in pion–pion scattering, but pion colliding-beam facilities are not yet available. Only two types of formation experiment have yielded boson resonances, namely proton–antiproton annihilation and electron–positron annihilation.

However, boson resonances are seen abundantly in experiments of the type

$$m_1 + B \rightarrow X + B \rightarrow (m_1 + m_2 + \ldots) + B$$

where X is the boson resonance, which

decays into two or more mesons. This type of experiment is called a "production experiment" because additional particles are created in the final state. In the reaction above, the baryon is not part of the resonating system although it is essential for the production of the resonance as well as for satisfying energy–momentum conservation.

The production reaction can be analyzed by measuring the recoiling baryon and deducing the "missing mass" that must be ascribed to the bosons. If a peak in the counting rate occurs at a particular value of missing mass, a resonance has been discovered (maybe!). Since the $\rho$-meson was discovered in 1961,[1] more than 30 boson resonances have been found. Figure 1 illustrates the numerous resonances in the mass spectrum of bosons produced by pion–proton scattering.[2]

### Decay rate

The number of decays per unit time is in constant proportion to the total number of particles remaining in the sample, leading us directly to the law of exponential decay $e^{-\Gamma t}$ familiar in radioactivity. The lifetime of the resonance is $\Gamma^{-1}$. From the uncertainty relation $\Delta E \cdot \Delta t \approx \hbar$ we know that the final state of the decay will not have a well defined energy. The spread of events in the resonance region is given by the Breit–Wigner formula

$$N(M) = \frac{\Gamma^2/4}{(M - M_0)^2 + \Gamma^2/4}$$

where $M$, the mass of the event, replaces energy as the variable. This expression has a maximum at $M = M_0$ and it drops to half maximum at $M = M_0 \pm \Gamma/2$. $M_0$ is called the "mass" of the resonance and $\Gamma$ is called the "width." To get an idea of the order of magnitude of $\Gamma$, we consider the Compton wavelength of the pion, $\lambda_\pi = 10^{-13}$ cm, as a typical range of the nuclear force, which leads us to a natural time unit for strong interactions

$$\tau = \lambda_\pi/c \approx 10^{-23} \text{ sec}$$

When the inverse lifetime is expressed in mass units, we find that $\Gamma$ is equal to the pion mass, about 140 MeV. This argument is only qualitative, and we should not be surprised if we find resonances that differ from this by an order of magnitude.

Resonances are further distinguished by their intrinsic quantum numbers. The nonstrange resonances are assigned four quantum numbers: spin (= angular momentum) $J$, parity $P$, isospin $I$, and $G$-parity. Spin and parity should be familiar from nonrelativistic quantum mechanics; isospin gives the charge multiplicity $2I + 1$, and $G$-parity is determined by whether the total number of pions is even or odd in an all-pion final state. Resonances are listed in the concise notation: $M_0$, $\Gamma$, $I^G$, $(J^P)$. For example the $\rho$-meson is written as: 765 MeV, 125 MeV, $1^+$, $(1^-)$.

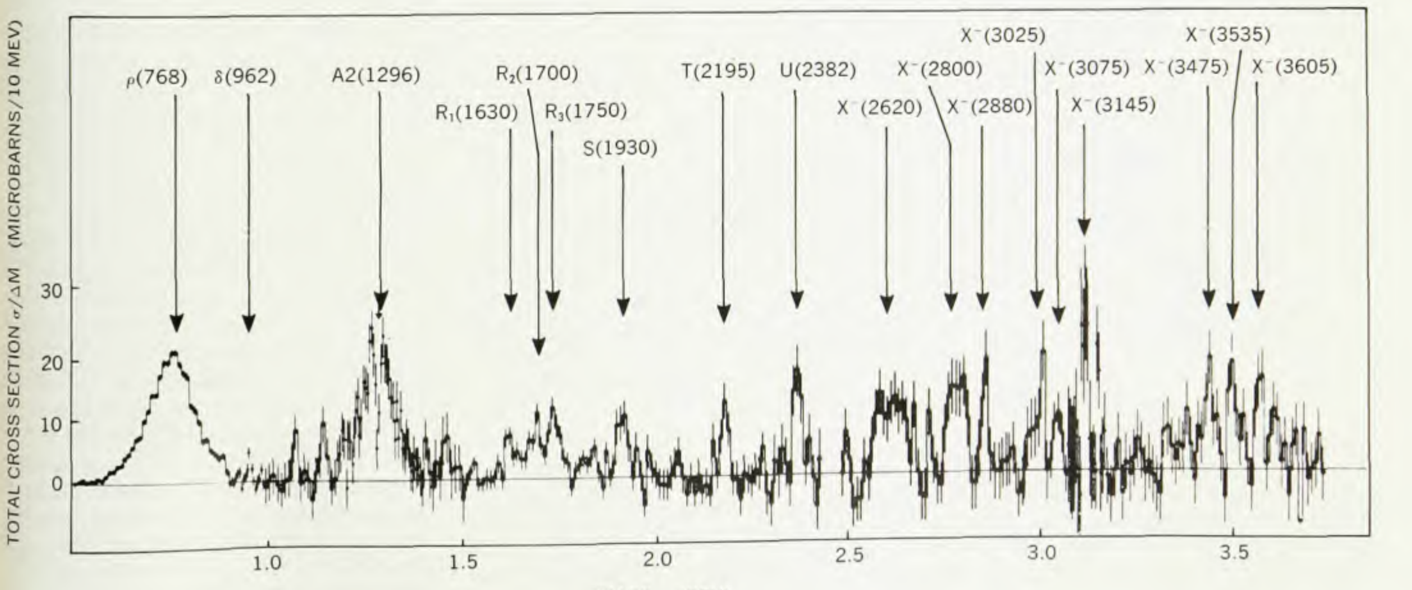
### A peculiar discovery

In 1964, a three-pion resonance with a mass near 1300 MeV and a width of about 100 MeV was discovered and christened[3-6] the "A2 meson." The most probable assignment of quantum numbers was $J^P = 2^+$ and $I^G = 1^-$. The A2 meson usually decays into $\rho\pi$ and occasionally into $K\bar{K}$ or $\eta\pi$.

The following year, the CERN missing-mass spectrometer group took data in the A2 mass region in the reaction $\pi^- + p \rightarrow p + X^-$. The missing-mass spectrum was scanned by the Jacobian peak method, which allows the observed angular distribution of the recoil proton to be converted into an $X^-$ mass spectrum.[7] Figure 2 shows the kinematics of the reaction. The data were taken at beam energies of 6 GeV/$c$ and 7 GeV/$c$. The square of the four-momentum transfer (essentially the proton lab momentum, because the proton was initially at rest) was about $|t| = 0.25(\text{GeV}/c)^2$. The data showed a dip in the middle of the A2 meson! Although statistically not very convincing, the effect was startling enough to be investigated in more detail. The feeling that something more than a statistical fluctuation was being observed was enhanced by the occurrence of the dip in the data for both incident energies.[8]

In 1967, new data were taken in the same reaction at 7 GeV/$c$.[9] The apparatus had been improved by adding digitized wide-gap wire spark chambers[10] in the forward direction to detect the decay particles of $X^-$, and a more accurate measurement of the recoil proton was also possible. Figure 3 illustrates the new spark chambers in action. Again, the mass spectrum showed a narrow dip of six standard deviations in the center of the A2 peak, now definitely suggesting a two-peak structure. The peaks were called $A2^L$ and $A2^H$ (for "lower" and "higher").

The data ruled out a single-peak hy-




Nonstrange boson resonances in the missing-mass spectrum obtained in the reaction $\pi^- + p \rightarrow p + X^-$, where $X^-$ is the boson produced. With the exception of the rho meson, all were discovered at CERN between 1965 and 1970 with the missing-mass and boson spectrometers. The recoil proton was observed in the Jacobian peak for missing mass below 2.4 GeV and in the forward direction above this value.
Figure 1

pothesis, but two incoherent Breit–Wigner curves gave a reasonably good fit with five free parameters and a confidence level of 15%. But the apparent symmetry of the data suggests something simpler, namely two coherent Breit–Wigner amplitudes with equal widths and destructive phase. This reduces the number of free parameters to three. A further reduction to only two free parameters occurs if the masses $M_1$ and $M_2$ in the two coherent amplitudes are assumed to be equal. This limiting case corresponds to a double pole in the S-matrix and is colloquially called a "dipole."

### The dipole

As one passes through an ordinary resonance, the phase shift $\delta$ advances rapidly through $\pi$. At a double resonance, $\delta$ advances by $2\pi$. As a consequence, the scattering amplitude, which is proportional to $\sin^2 \delta$, has two symmetric peaks. Between them is an exact zero. The Breit–Wigner formula is replaced by

$$N(M) = \frac{\Gamma_{DP}^2 (M - M_0)^2}{[(M - M_0)^2 + \Gamma_{DP}^2/4]^2}$$

where $\Gamma_{DP}$ gives the spacing between the peaks.[11,12] This expression differs from that for the case of two coherent Breit–Wigner amplitudes only in the wings, where the dipole is stronger. An investigation of a dipole resonance gives the rather surprising nonexponential solutions for the decay amplitudes

$$(1 \pm \Gamma_{DP}t/2)e^{-\Gamma_{DP}t/2}$$

and

$$(\Gamma_{DP}t/2)e^{-\Gamma_{DP}t/2}$$

The same data that gave only a 15% confidence level for two incoherent Breit–Wigner curves gave a 70% confidence level for the dipole. It is extremely difficult to distinguish a dipole from two coherent Breit–Wigner amplitudes experimentally, because only the wings are different. When fitting data to the dipole formula, one has to fold in the experimental resolution $\Gamma_{exp}$ as usual. This will decrease the depth of the dip, and when the experimental resolution exceeds the separation of the peaks, the dip will disappear.

### Properties of the A2

The A2 meson now posed several questions that could be answered only by further experimental work:

▶ Must we assume quantum interference between the two halves of the A2 to explain the splitting?

▶ Are the spin and parity of the two halves identical?

▶ Is the splitting independent of the bombarding energy and momentum transfer?

▶ Do both halves have the same decay channels?

▶ Is the splitting the same for the positive, negative and neutral A2?

If the answer to all these questions is "yes," the A2 is indeed an unusual object that will not fit easily into present particle theories. For, if the A2 is two particles with the same quantum numbers, it adds an uninvited tenth guest to its SU(3) nonet. On the other hand if it is a single object, the dipole, we would expect the other members of the nonet to exhibit the same behavior.

The bulk of the experimental work since 1965 supports an affirmative answer to all the above questions, at least for the A2⁻. The first two points are very well established, the others less so. There is no compelling evidence that would support a negative answer to any of the questions. Some data exist that can be interpreted as an indication of a splitting in two other members of the A2's nonet. To echo a familiar cry, more data are needed to solve the puzzle.

We are dealing with an effect that is not easy to measure. What are the reasons?

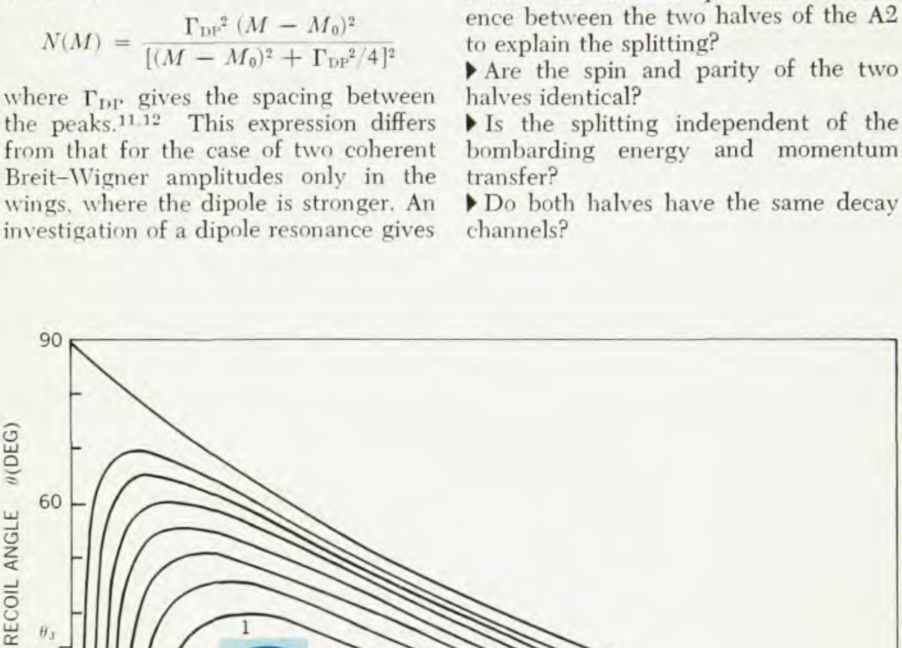
▶ The mass resolution of the detection apparatus $\Gamma_{exp}$ must be good, better than about 20 MeV FWHM.

▶ Statistics must be large, say a few hundred events per 10 MeV bin. This criterion is extremely severe, but it will prevent us from drawing all kinds of wrong conclusions from statistical fluctuations.

▶ The data must be plotted in bins of about 1/3 $\Gamma_{exp}$ to obtain optimum sensitivity.

▶ All experimental conditions during the full period of data acquisition must be extremely steady. Any small shift in incoming momentum, proton-momentum measurement, and so on, will wash out the effect.

This difficult experimental investigation has been pursued at many laboratories, and it must be said that the A2 has been a bone of contention as well as a puzzle.

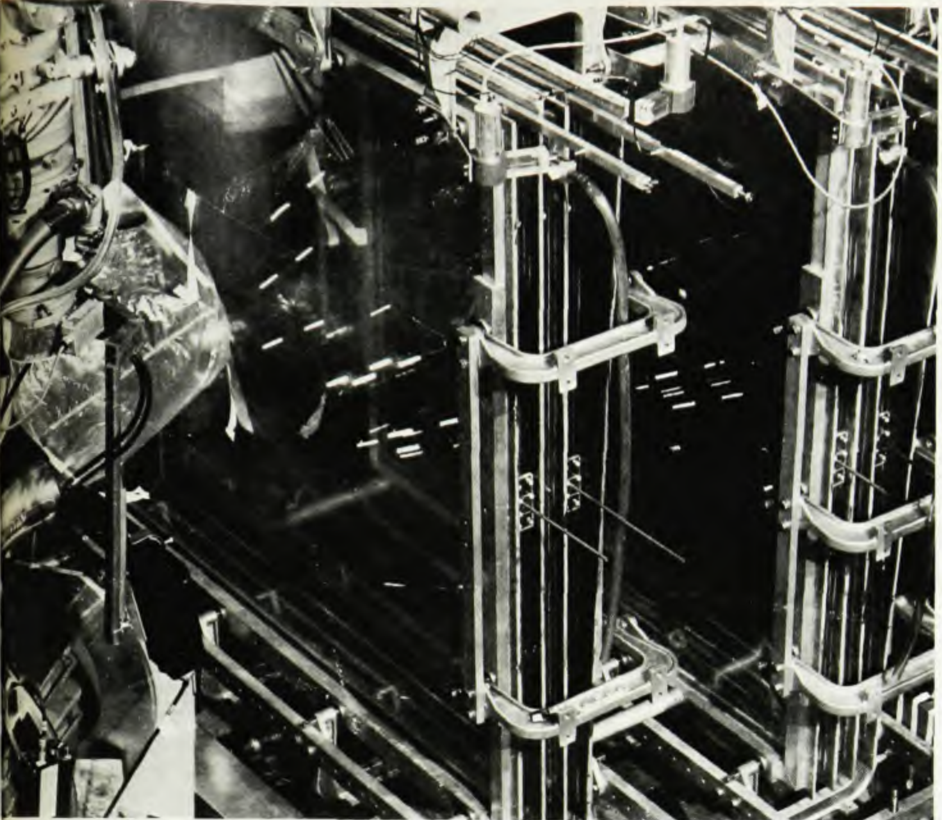



**Kinematics of the detection process** in the reaction $\pi^- + p \rightarrow p + X^-$. The recoil angle $\theta$ of the proton in the lab is plotted as a function of proton lab momentum $p$ for a bombarding momentum of 2.6 GeV/c. Each contour represents a different missing mass. If the proton is observed in the Jacobian peak (region 1), an accurate determination of $\theta_J$ and a rough measurement of $p$ specifies the missing mass. Another technique is to observe a forward-scattered proton (region 2), for which the momentum transfer is a minimum. In this case an accurate measurement of the momentum is required with only rough angular resolution. The Jacobian peak angle $\theta_J$, the minimum momentum transfer $p_{min}$ and the contour for missing mass = 1.3 GeV are in color. The contour originating at 90° represents elastic scattering with a missing mass equal to the mass of the pion. In practice, a particular mass region is not studied at a given beam momentum by both techniques. Figure 2

### Further work

As a continuation of the 1967 work, the CERN boson spectrometer group, as the missing-mass spectrometer group had been renamed, measured the A2 again in 1968, this time at bombarding energies of 2.55, 2.60 and 2.65 GeV/c. Instead of detecting the recoil proton in the Jacobian peak, they detected a forward-scattered proton with minimum four-momentum transfer (see figure 2 for the kinematics). In addition, the sonic spark chambers in the proton telescope were replaced by wide-gap wire spark chambers.[10]

These data[13] taken at threshold showed the splitting with a statistical significance of about five standard deviations. The fits to the sum of all data for each of three hypotheses is shown



**Wide-gap spark chambers** from the CERN boson spectrometer. Particle reactions occur in the hydrogen target visible as a slotted horizontal cylinder at the lower left. Two events, separated by only 10 milliseconds, have here been superimposed; the spark tracks can be traced back to their separated vertices. Figure 3

in figure 4. The inevitable conclusion is that we are not dealing with two independent resonances with different quantum numbers, because the confidence level for the two incoherent Breit–Wigner curves is so low. Rather, we are most likely seeing two nearby objects of the same kind, or possibly only one—the dipole.

In the same year, 1968, a Brookhaven bubble-chamber group[14] saw the splitting of the A2 at 6 GeV/$c$ bombarding energy in the reaction

$$\pi^- + p \rightarrow p + \pi^- + \text{missing mass}$$

However, when they plotted the $K_1^0K_1^0$ final state, they observed only one narrow peak, approximately at the position of $A2^H$. The spin-parity assignment at that time rested strongly on the $K\bar{K}$ decay mode; if the observation were correct it could be interpreted to mean that the $A2^L$ and $A2^H$ have different quantum numbers.

The argument is as follows: $G$-parity, isospin and angular momentum for the $K\bar{K}$ system are linked by the relation

$$G = (-1)^{I+L}$$

Hence an isotriplet that decays into $K\bar{K}$ must have even spin. Furthermore, the parity must be positive because the intrinsic parity of the $K\bar{K}$ system is positive and

$$P = P_{\text{intrinsic}}(-1)^L$$

The 0+ state is ruled out by the $\rho\pi$ decay, because there is no way to combine these particles in an $I = 1$, $J = 0+$ state. We are left with $2^+$, $4^+$, $6^+$, . . . All assignments higher than $2^+$ are improbable because the A2 mass is so close to the $K\bar{K}$ threshold. This threshold argument and the absence of the $A2^L$ in the $K_1^0$, $K_1^0$ effective mass led the Brookhaven group to prefer the $1^-$, $3^-$ . . . series for the spin-parity assignment of the $A2^L$.

### Decay into $K\bar{K}$

However, early in 1969, a CERN–Collège de France–Liverpool bubble-chamber group[15] published proton–antiproton annihilation data at incident antiproton momenta of 0.0, 0.7 and 1.2 GeV/$c$. In $K_1^0K^\pm$ effective mass they saw a split A2 as shown in figure 5. Their single-peak hypothesis had a confidence level of 4%, while the dipole gave 65%. The central mass value and width differed by less than one standard deviation from the CERN data shown in figure 4.

A spin-parity analysis of the CERN 1967 data[16] also favored the $2^+$ assignment for both halves but was statistically weak, especially for the $A2^H$.

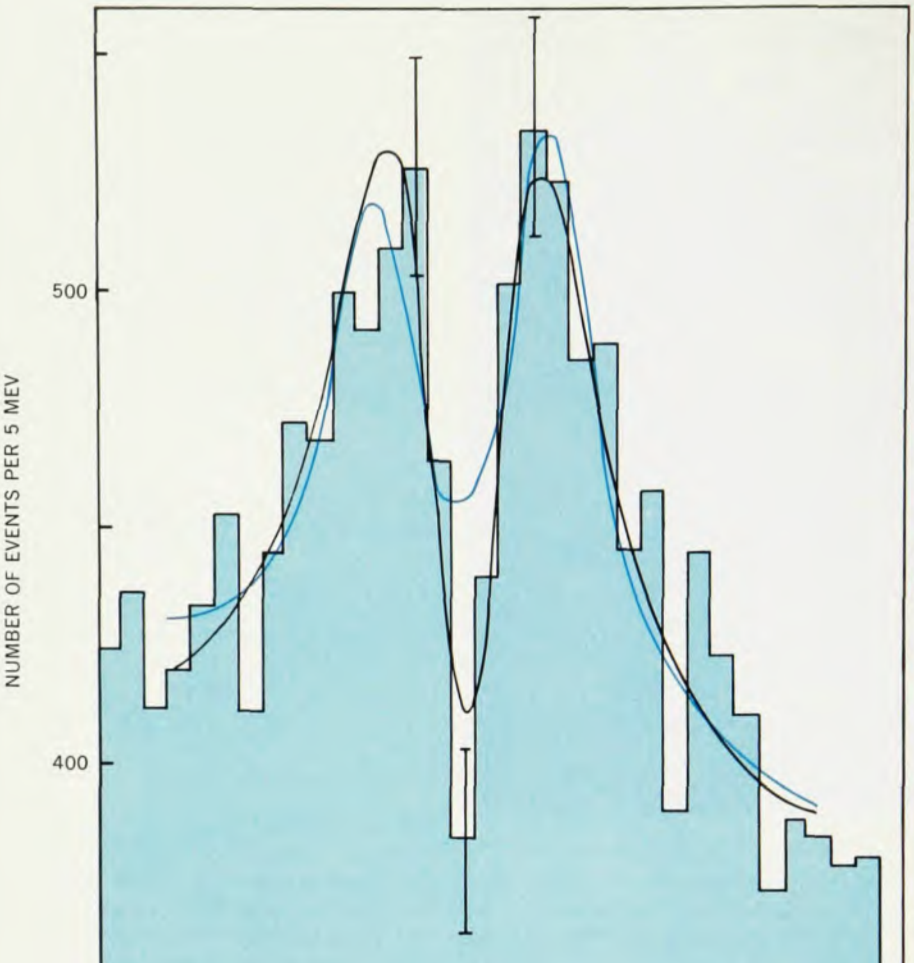
In the same year, three more experiments presented data related to the A2 puzzle; unfortunately their statistics are rather poor:

- A Liverpool bubble-chamber group saw a 2.5 standard-deviation splitting in proton–antiproton annihilations into $\rho^0\pi^\pm$ at 1.2 GeV/$c$ beam momentum.[17]
- A European bubble-chamber collaboration observed a 2.8 standard-deviation splitting in $\pi^+ + p \rightarrow p + A2^+$ at 5 GeV/$c$ in the $\rho^0\pi^+$ final state.[18]
- A team from Wisconsin took data at the rapid-cycling PPA bubble chamber in a negative pion beam at 2.4 GeV/$c$ and saw a 2.9 standard-deviation splitting in their missing-mass spectrum of the recoil proton.[19]

In the fall of 1969, the CERN boson-spectrometer crew once more took data[20,21] at 7 GeV/$c$ in $\pi^-p$ reactions returning to the Jacobian-peak method. The trigger demanded an incoming particle, a recoil proton in the proper momentum window and at least one charged particle into the forward solid angle covered by two large wide-gap wire chambers.[10] Events of the type $A2^- \rightarrow K^- + K_1^0$ with $K_1^0 \rightarrow \pi^+ + \pi^-$ were identified in several steps by applying topological, geometrical and kinematical criteria. The correctness of this selection has been checked by fitting a lifetime to the vertex distribution of the $K_1^0$, which agreed well with the known value. The $K_1^0K^-$ mass spectrum is shown in figure 6. A dip of about four standard deviations is seen; a single Breit–Wigner curve has a confidence level of about 5% whereas the dipole gives a confidence level greater than 60%. With data taken in the same experiment but with three pions in the final state, a Dalitz-plot analysis has been carried out by calculating the momenta of the three pions from their directions. The reaction is

$$\pi^- + p \rightarrow p + A2^- \rightarrow$$
$$p + \rho^0 + \pi^- \rightarrow p + \pi^+ + \pi^- + \pi^-$$

It was possible to determine the spin-parity assignment of the $A2^L$ and $A2^H$ separately. Only the $2^+$ assignment




**Fits to the two-peak structure** of data from the CERN missing-mass and boson spectrometer group for the A2, 1965–68. The black curve is the fit for two coherent Breit–Wigner amplitudes or a dipole (these two can not be distinguished); the colored curve is the fit for two incoherent Breit–Wigner curves. The incoherent case is ruled out by a confidence level of 0.2%, while the coherent and dipole fits have equal confidence levels of 40%.
Figure 4

for both the $A2^L$ and the $A2^H$ gives a confidence level greater than 10%, while the assignment $1^-$, $1^+$ (s-wave), $1^+$ (d), $2^-$ (p), and $2^-$ (f) all give a confidence level much less than 0.01%. The ratio of resonance to $\rho\pi$ and $3\pi$ background, which must be known for such analysis, has been determined experimentally from the data.

## Conflicting evidence

A new experimental contribution to the A2 came in the spring of 1970[22] when the LRL bubble-chamber group A at Berkeley investigated at 7 GeV/$c$ the reaction $\pi^+p \rightarrow pA2^+$. In none of their three final states ($\rho^0\pi^+$, $\eta\pi^+$ and $K^+K_1{}^0$) do they see a splitting, though they claim to have an experimental resolution of about ±5 MeV. They base their conclusion of no splitting on the sum of $K^+K_1{}^0$ and $\eta\pi^+$ events and independently, on the $\rho^0\pi^+$ events. In both cases they obtain a confidence level of about 13% for a single Breit–Wigner curve and a confidence level of about 0.3% for a dipole. However, if for the first set of events one fits the data, not from 1000 MeV to 1600 MeV as they do, but only from 1150 MeV to 1450 MeV using their background and resonance assumptions, one obtains an acceptable confidence level for the dipole. One also obtains an acceptable dipole fit over the whole mass spectrum if one assumes a second-order background. Furthermore, one has to note that the extremely crucial background behavior at both ends of the spectrum is based on 2–6 events per 10-MeV bin. The same procedures increase the confidence level for a dipole in the $\rho^0\pi^+$ events by a considerable amount. Aside from statistics and background considerations, one must bear in mind the very general fact that it is much easier *not* to see a splitting than to see it, because of a variety of resolution-killing effects that are normally hard to track down, both in counter and bubble-chamber experiments.

Exciting new results on the *neutral* A2 were reported, at the Kiev International High Energy Conference in September, by T. Massam of the group at CERN headed by A. Zichichi. In the first reported observation of the splitting in $A2^0$, the CERN counter group measured the recoil neutron in the charge-exchange reaction

$$\pi^- + p \rightarrow n + A2^0$$

at a beam momentum of 3.2 GeV/$c$. They saw a marked dip at the center of the $A2^0$. Confidence levels for a single peak, incoherent double peak and dipole were 1%, 23% and 67% respectively.

## Dependence of splitting

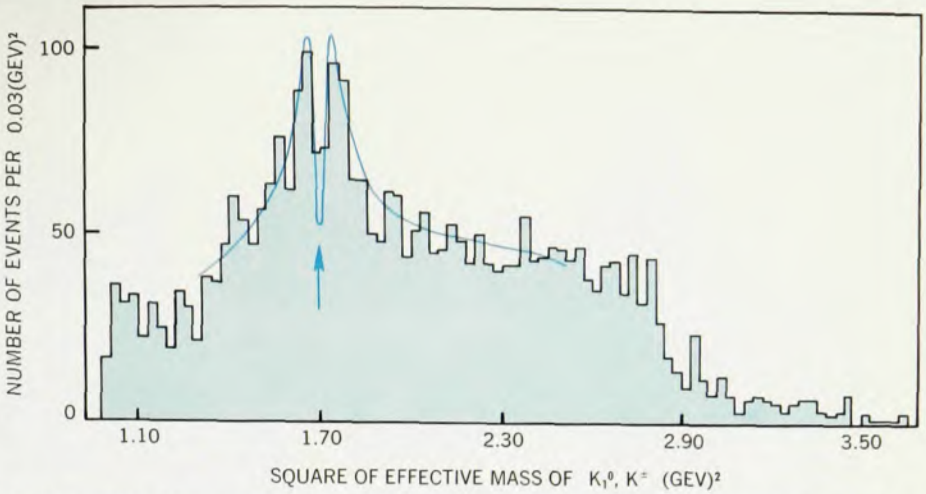
To arrive at some conclusions concerning the A2 splitting we will look for variables the effect may depend on. The dependence or independence might give a clue to the nature of the A2. We will discuss the possible dependence of the A2 splitting on four quantities: bombarding energy, final state, production reaction and momentum transfer.

The effect of symmetric splitting has been observed significantly at threshold and at 6 and 7 GeV/$c$ by the CERN counter group. At the present time, no data shed doubt on the invariance of the A2 splitting with bombarding energy.

The most significant data show the effect in missing mass with negative charge, or $\rho\pi$. There is considerable indication for the splitting in the $K\bar{K}$ final state (CERN counter and bubble-chamber groups) and some indications for $\eta\pi$ (the counter group). We therefore conclude that the A2 splitting does not have any dependence on the final state of the decay.

The bulk of the data have been taken for $A2^-$ produced in negative pion beams. Supporting evidence in $A2^+$ comes from a European bubble-chamber collaboration[18] and from a small CERN sample.[13] Strong support for splitting in A2± mesons produced in $p\bar{p}$ annihilation comes from the CERN bubble-chamber group[15] and Liverpool.[17] Evidence against the splitting in A2+ comes from the Berkeley bubble-chamber group.[22] We conclude that, at the present time, no strong evidence that the effect depends on the nature of the bombarding particles exists, but we do not exclude the possibility that the charge state of the bombarding pion may play a role.

The most convincing data for the A2 splitting have been taken in counter experiments (missing-mass and CERN boson-spectrometer group). In these experiments, low values of momentum transfer were inaccessible because the recoil proton has to traverse a minimum amount of liquid hydrogen, wire planes, mylar windows and scintillation-counter material. As a result, the data from the counter experiments include only events with $|t|$ greater than about 0.2 $(\mathrm{GeV}/c)^2$. Bubble-chamber data cover the full range of $t$ from zero upwards, but the statistics for $t \leq 0.2$ $(\mathrm{GeV}/c)^2$ are not good because the A2 is not produced very abundantly at low $t$ values. Therefore, we do not share the belief of many people that at the present time, there is compelling proof of a $|t|$ dependence for the A2 splitting.



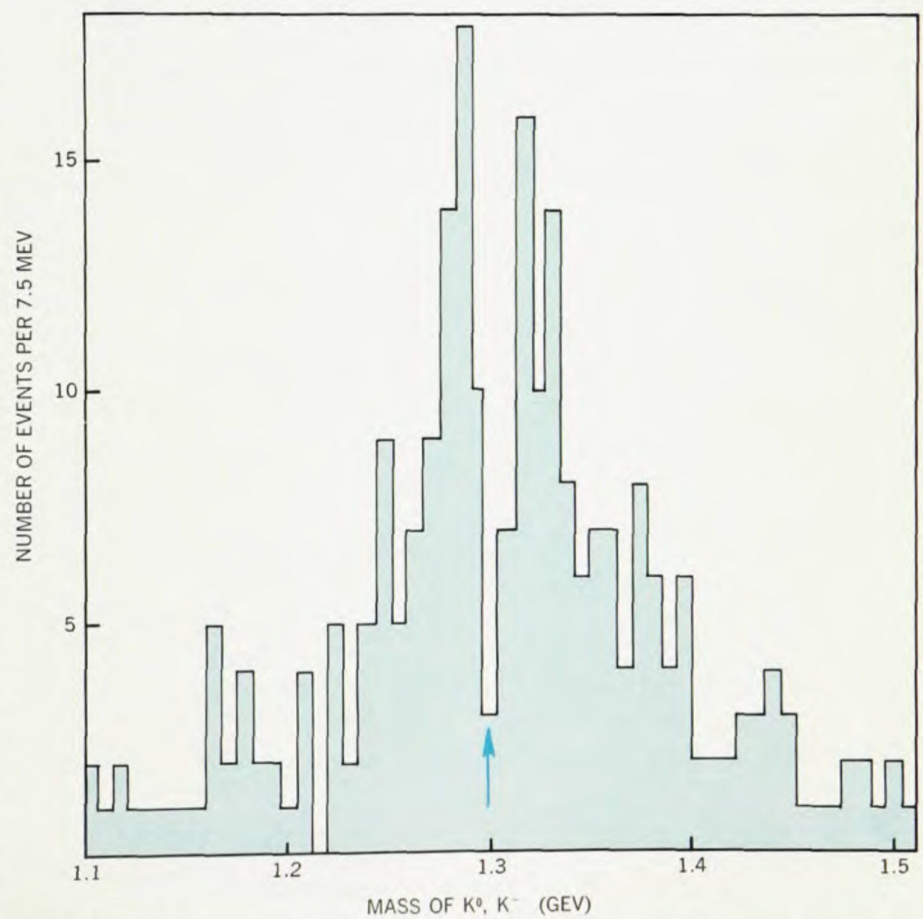

**Proton–antiproton annihilation** shows evidence for a split A2. The dip at the A2 (mass)$^2$, shown by the colored arrow, in the $K_1^0K^+$ effective mass spectrum indicates that the A2 splitting is independent of the production reaction. The data were taken by a CERN-College de France-Liverpool bubble-chamber group. Figure 5

### A universal solution?

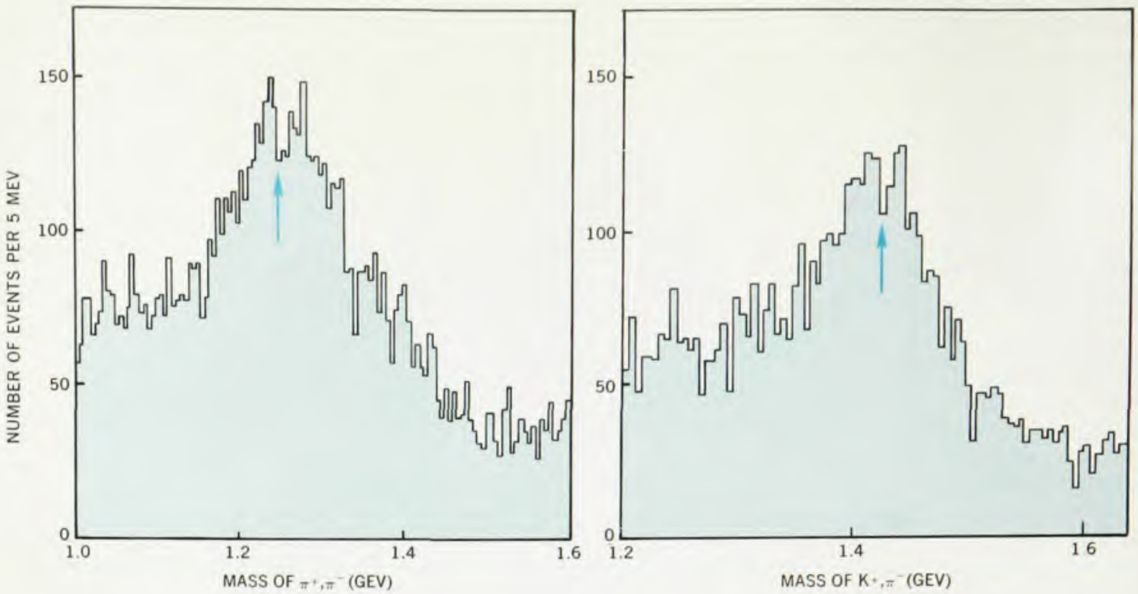
The A2 meson produced in the reaction $\pi^- + p \rightarrow p + A2^-$ shows a two-peak structure, which can not be explained by assuming that there are two resonances having nothing to do with each other but happening to have approximately the same mass. Two coherent Breit–Wigner amplitudes, or a dipole distribution, reflect the apparent symmetry of the data and gave a good fit. There is no compelling evidence that the two-peak structure depends on bombarding energy, production reaction, four-momentum transfer or final state. This means that a "universal" solution is still possible, but we must keep in mind that there is no proof yet that this is correct.

From a theoretical point of view, the two-peak structure of the A2 meson is surprising and not understood, because the quark–antiquark model, which works so well for other mesons, has no room for two states with the same quantum numbers and practically the same mass. Several more involved models have been put forward. One suggests that an $I = 1$ state and an $I = 2$ state mix by virtue of the electromagnetic interaction, which can violate isospin symmetry.[23] Another predicts that two A2 mesons are produced, one coupled to $\rho$ exchange, the other to $f^0$ exchange. According to a very general dipole formalism, any resonance shape is possible: one peak, two peaks, symmetry, no symmetry, and so on.[24] None of the proposals is convincing, and we believe that it is fair to say that nobody knows at the present time what the A2 splitting means.

Clearly, more experimental work on the A2 is needed. But other studies can help unravel the puzzle. We know that the spin-parity assignment of both halves of the A2 is 2+. There are other resonances with $J^P = 2^+$ that together form an SU(3) nonet: the isotriplet A2, the isodoublets K* (1420) and the




**Final state of $K_1^0K^-$** for the decay of the A2$^-$. The colored arrow marks the dip at 1300 MeV, the mass of the A2. These data, taken by the CERN boson-spectrometer group in 1969, support the contention that the A2 splitting is independent of the final state of the decay. Figure 6




**Splitting indicated for two other members of the A2's $2^+$ SU(3) nonet. The $f^0(1260)$ spectrum (on the left) and the $K^*(1420)$ spectrum (on the right) show distinct dips in the central mass bins, although the Berkeley bubble-chamber group that took the data concludes that neither has an acceptable dipole fit. Figure 7**

two isosinglets $f^0$ (1260) and $f^{0\prime}$ (1514). The thing to do is to investigate the fellow members of the A2 in the $2^+$ nonet to see if they show the same double structure. If they do, it would probably require a fundamental revision of our ideas about particle physics, possibly the introduction of a new quantum number. If the $K^*$ (1420) and the $f^0$ particles do not exhibit a similar splitting, and if the same is true for all other boson resonances, we are probably forced to conclude that an accident of nature has occurred in the A2-meson region and the general interest in the A2 splitting will fade away.

The $K^*(1420)$[25] and the $f^0(1260)$ have been observed by the Berkeley bubble-chamber group A. Their data is shown in figure 7. They conclude that in spite of a distinct dip in the central mass bins, neither of these objects is split because a dipole fit has a confidence level of less than 1% in both cases. The splitting may in fact not exist or it may be concealed by an underestimated mass resolution, background problems, insufficient statistics, or unstable conditions during the data-acquisition period. The situation in the $2^+$ nonet is far from being conclusive, and a stable counter experiment with high statistics and good mass resolution is needed. I have proposed such an experiment in collaboration with a group at Carlton University in Ottawa. This experiment would be performed at Brookhaven in a high-intensity kaon beam when operations resume after the 1971 AGS shutdown.

* * *

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