Prediction and discovery of the Ω^-

In 1962 Gell-Mann predicted the existence of the Ω^- particle, needed to complete the baryon decuplet. His prediction included a mass and lifetime estimate both of which turned out to be quite close to the later determined experimental values.

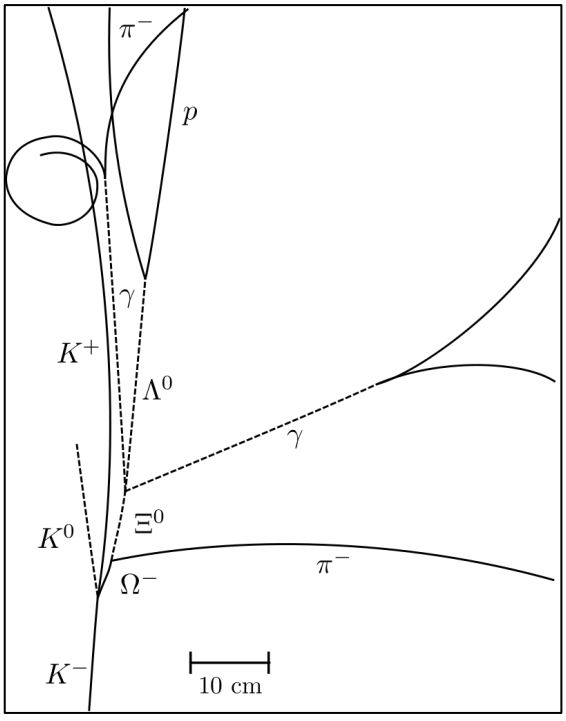
To estimate the mass Gell-Mann extrapolated from the other members of the spin-3/2 decuplet: (S = 0): $m_\Delta \approx 1235$ MeV, (S = –1): $m_\Sigma \approx 1385$ MeV, (S = –2): $m_{\Xi^*} \approx 1530$ MeV. From these values what would you expect for the S = –3 m_Ω?

Members of the spin-3/2 baryon decuplet typically decay after $\sim 10^{-23}$ s (via the strong interaction, conserving B and S) into a lighter baryon (from the baryon octet) and a meson (from the meson octet). Thus, one would expect the following decays:

$$\Omega^- \rightarrow \Xi^o + K^- \qquad \text{or} \qquad \Omega^- \rightarrow \Xi^- + \overline{K}^0$$

Verify that these two decays conserve both B and S. For a decay to be "kinematically allowed" the mass of the decay products cannot exceed the mass of the original particle. Noting that $m_\Xi \approx 1320$ MeV and $m_K \approx 500$ MeV, are the above two decays kinematically allowed? Explain how this result led Gell-Mann to predict a lifetime for the Ω^- particle of $\sim 10^{-10}$ s (more than 10^{12} times longer than the other members of the baryon decuplet!).

On the back of this page is a 1/2-size reproduction of the original 1964 photograph, from the 240 gallon liquid hydrogen bubble chamber at Brookhaven National Lab, that provided the first experimental evidence for the existence of the Ω^-. The parallel lines in the photo, moving up and slightly right, are K^- particles from a 5 GeV K^- beam directed into the bubble chamber. Below is an interpretation of the relevant particle tracks. (Note that neutral particles leave no tracks). The Ω^- is produced in a K^- collision with a hydrogen proton: $K^- + p \rightarrow K^o + K^+ + \Omega^-$. Measure the omega-minus track length and, assuming it is travelling at $\sim 0.5c$, estimate its lifetime. Also, verify that the Ω^- decay mode shown below is kinematically allowed ($m_\pi \approx 140$ MeV).



kaon strangeness:

K^- : $S = -1$

K^+ : $S = +1$

K^o : $S = +1$

$\overline{K}^o$: $S = -1$