

Ξ and Ω Resonances

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Most of our present knowledge of Ξ and Ω resonances stems from the low-statistics data samples recorded in the 1960s–1980s using K^- beams and in the 1980s and 1990s using hyperon (Σ^-, Ξ^-) beams. This is because (1) they could only be produced as a part of a final state, and so the analysis is more complicated than if direct formation were possible, (2) the production cross sections are small (typically a few μb), and (3) the final states are topologically complicated and difficult to study with electronic techniques. Thus, early information about Ξ resonances came entirely from bubble chamber experiments, where the numbers of events were small, and only in the 1980s did electronic experiments make any significant contributions.

In recent years, the two ground states, $\Xi(1320)^-$ and $\Xi(1530)^-$, have been observed in photoproduction by the CLAS Collaboration in the reaction $\gamma p \rightarrow K^+ K^+ \Xi_{\text{miss}}^{(*)}$ [1]. New opportunities for studying multi-strange hyperons have also emerged from the high-energy collider experiments, amongst others, Belle, BESIII, and LHCb. At these facilities, light-flavor baryon resonances are copiously produced in the decays of heavy baryons containing a charm or bottom quark, or in the decay of heavy-flavor mesons. The available high-statistics data samples provide a rich source for studying multi-strange hyperons. For example, excited Ξ baryons are produced and have been studied in the decay of the charmed Λ_c^+ into $(\Sigma^+ K^-)_{\Xi(1690)} K^+$ by the Belle Collaboration [2] and into $(\Xi^- \pi^+)_{\Xi^*} K^+$ by the BaBar Collaboration [3], but also by Belle in the decay $\Xi_c^+ \rightarrow (\Xi^- \pi^+)_{\Xi^*} \pi^+$ [4] with high statistical quality. Clear signatures are observed for the decuplet ground state, $\Xi(1530)$, and for the lowest-mass excitations, $\Xi(1620)$ and $\Xi(1690)$. The BESIII Collaboration studied Ξ^* production in reactions such as $e^+ e^- \rightarrow \psi(3686) \rightarrow (K^- \Lambda)_{\Xi^*} \bar{\Xi}^+$ and has observed structures associated with the $\Xi(1690)$ and $\Xi(1820)$ resonances [5]. Even a partial wave analysis (PWA) was performed to study the properties of these intermediate state Ξ^* hyperons. However, such studies from $c\bar{c}$ decays are still statistically limited and nothing of significance has been observed for masses beyond 1.9 GeV. Finally, the LHCb Collaboration studied Ξ^* resonances in high-energy pp collisions. The results are based on an analysis of the reaction $\Xi_b \rightarrow J/\psi (\Lambda K^-)_{\Xi^*}$ and the first observation of $\Xi(1690)$ and $\Xi(1820)$ in the decay of Ξ_b^- was announced [6]. Masses and widths have been determined with improved precision in an amplitude analysis of the $K^- \Lambda$ mass distribution. Large uncertainties in the width of excited Ξ resonances remain. The assignment of the $\Xi(1530)$ to the ground-state decuplet is undisputed and the corresponding $J^P = 3/2^+$ quantum numbers have been experimentally confirmed by the BaBar Collaboration [3]. With few exceptions, experimental analyses and theoretical approaches suggest $J^P = 1/2^-$ and $J^P = 3/2^-$ for $\Xi(1690)$ and $\Xi(1820)$, respectively [7]. All other J^P assignments for Ξ resonances are speculative.

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The $\Omega(2012)^- \rightarrow \Xi^0 K^-$ ($\Xi^- K_S^0$) was discovered by Belle in 2018 in the decays of the $b\bar{b}$ mesons $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ [8]. The ground-state Ω^- is copiously produced in the decay $\Xi_c^0 \rightarrow \Omega^- K^-$ and with lower statistics in $\Omega_c^0 \rightarrow \Omega^- \pi^+$. Such data samples were used by the BaBar Collaboration for a spin measurement of the Ω^- hyperon [9], for instance. The most recent addition to the family of Ω baryons was reported by the BESIII Collaboration in 2025 in the process $e^+e^- \rightarrow \Omega(2109)^-\bar{\Omega}^+$ [10].

Table 1. Our estimate of the status of the Ξ resonances. Only those with an overall status of *** or **** are included in the Baryon Summary Table.

Particle	J^P	Overall status	Status as seen in —				
			$\Xi\pi$	ΛK	ΣK	$\Xi(1530)\pi$	Other channels
$\Xi(1320)$	1/2+	****					Decays weakly
$\Xi(1530)$	3/2+	****	****				
$\Xi(1620)$		**	**				
$\Xi(1690)$	1/2-	***	**	***	**		
$\Xi(1820)$	3/2-	****	**	****	**	**	
$\Xi(1950)$		***	**	**		*	
$\Xi(2030)$		***		**	***		
$\Xi(2120)$		*		*			
$\Xi(2250)$		**					3-body decays
$\Xi(2370)$		**					3-body decays
$\Xi(2500)$		*		*	*		3-body decays

**** Existence is certain, and properties are at least fairly well explored.
 *** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, *etc.* are not well determined.
 ** Evidence of existence is only fair.
 * Evidence of existence is poor.

References:

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