key questions are: is V_Σ attractive and large enough to provide bound Σ states? And if so, is W_Σ small enough to lead to states which are relatively stable with respect to the $\Sigma N \to \Lambda N$ conversion?

Unfortunately, existing two-body ΣN data do not place strong constraints on the form of the ΣN potential $V_{\Sigma N}$ so even the sign of V_Σ cannot be reliably predicted. However, V_Σ can be assumed to be attractive if it is calculated using optical models fitted to Σ-atom level shifts and widths. With this assumption, V_Σ would be shallower than the corresponding Λ-nucleus potential and on the order of 20 MeV. The assumption would also imply agreement with the data shown in Fig. 5. However, a direct measurement of V_Σ is needed in order to resolve contradictory experimental data. This can be done in the same way as for Λ-hypernuclei with the (K^-, π^-) reaction, and for ordinary nuclei with the (e,e'p) reaction by analyzing the shape of the energy distribution of the Σ states produced in quasi-free scattering. But such an analysis requires data with good statistics and therefore high quality beams.

Another key point is to examine mechanisms which lead to the suppression of Σ decay widths, and thus to small values of W_Σ in finite nuclei. Pauli and dispersion effects have been considered, as well as the role of the spin dependence of the $\Sigma N \to \Lambda N$ conversion process [7]. In this case, the narrow Σ structures should show up best in the (K^-, π^-) reaction arising at a very low momentum transfer q because, as discussed for the Λ hypernuclei case, for large values of q, states with spin $J \neq 0$ are strongly excited and these states are expected to have a large energy width. The data of Fig. 5 measured at CERN, unlike other experiments, were obtained at low q.

Future Perspectives

In addition to Λ hypernuclei with a single Λ, two species of double-Λ hypernuclei have been observed [9] in emulsion experiments in the '60's, namely ${}^{10}\mathrm{Be}_{\Lambda\Lambda}$ and ${}^{6}\mathrm{He}_{\Lambda\Lambda}$. The binding energies $B_{\Lambda\Lambda}$ of these two hypernuclei have also been measured. However, the fact that all attempts to theoretically reproduce these findings have so far failed makes it important to check the original data using modern experiments. This could be done by studying, as suggested in a complete review on hypernuclear physics [9], the (K^-, K^+) reaction on nuclei. This process can produce either Ξ-hypernuclei ($S = -2$) or double-Λ hypernuclei. The latter are closely related to the existence and stability problem of the H particle, which was predicted some 20 years ago [10] as an exceptionally stable six quark bound state with a typical mass of 80 MeV below the threshold. Confirmation of the existence of double-$\Lambda\Lambda$ hypernuclei decaying through two successive weak decays $\Lambda \to \pi + p$ would provide strong evidence against the existence of the H particle with a very small mass (less than $2M_\Lambda$-$B_{\Lambda\Lambda}$), otherwise the H would be emitted much more rapidly than the weak decay instead of staying in the nucleus as $\Lambda\Lambda$.

Conclusions

The study of hypernuclear physics has proved to be essential in checking nuclear structure models, and for providing data describing the baryon-baryon interaction in the energy domain that cannot be probed by baryon-baryon scattering. The spin orbit force has been found to very small in Λ hypernuclei and there are indications that it could be much larger in Σ hypernuclei than in ordinary nuclei. However, the most attractive feature of hypernuclear physics is the possibility of investigating a new branch of nuclear physics that seeks to distinguish between different behaviours of the baryon, depending on whether it is free or embedded in the nuclear matter. Such differences would arise, for example, between the decays of the Λ, Σ and Ξ-hypernuclear states.

New experiments having a much higher statistical significance are needed to clarify some key points such as the Σ or double-$\Lambda\Lambda$ hypernuclei cases. European physicists have been very active, both in theoretical and experimental aspects, but since the shutdown of CERN's kaon beams, experiments now take place almost exclusively at Brookhaven in the USA and KEK in Japan.

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Material Processing under High Gravity

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A melt placed in a centrifuge is submitted to an "effective gravity field" which is more intense than the earth's field, and is also non-uniform. It is no surprise that crystal growth from such melts may have specific characteristics. Mass transport is affected: ionic crystals can be grown from centrifuged solutions hundreds times faster than is usual (P.J. Shlichta, W.R. Wilcox, USA, in the 1970's); light impurities may be expelled, which is important for proteins; structures obtained under constitutional supercooling conditions vary with the convection regime.

Studies of centrifuged eutectics are active in the USA, Hungary, China, Czecho-Slovakia and the USSR. New materials may even be found under high gravity. After the announcement by R. Parfeniev (FTI, Leningrad) and L. Regel (IKI, Moscow) of a magnetic moment of up to 130 K in BiSrCaCuO crystals remelted under high gravity, the centrifuge and ultracentrifuge machines existing in many biology and civil engineering laboratories may have to face a rush of new customers!

Gravity may stabilize or destabilize the convection currents in the melt. H. Wiedemeier (Rensselaer Polytechnic, NY, USA) and L. Regel found large differences in the growth from vapour when gravity is parallel or antiparallel to the growth direction. G. Müller (Erlangen University, Germany) showed in 1980 that the impurity striations found in InSb for destabilizing conditions could be removed if the melt was centrifuged, and explained it quantitatively in 1990 by the action of Coriolis acceleration. For Bridgman growth under stabilizing conditions of PbTe:Ag, H. Rodot (CNRS, France) and L. Regel found an inhibition of segregation for a well-defined value of the effective gravity.

Specialists of fluid dynamics are very active in improving their models. Some of them (W. Arnold, A. Chait and W.R. Wilcox, Clarkson University, NY, and NASA-Lewis, USA; G. Labrosse and A. Fikri, Orsay University, France) build rigorous descriptions of the convection regime in centrifuged melts. Others (H. Azuma, National Aerospace Laboratory, Japan; N. Baturin, IKI, Moscow, and J.C. Legros, Brussels University, Belgium) also try to describe, in simplified terms, the segregation effects. It is felt that these theories will soon generate the leading criteria for designing new experiments.

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