

Spin at Lausanne

Part of the apparatus used at the Argonne ZGS to measure polarized proton-proton cross-sections. One year after the closedown of the ZGS, these results are still a talking point wherever spin physics is discussed.

(Photo Argonne)

From 25 September to 1 October, some 150 spin enthusiasts gathered in Lausanne for the 1980 International Symposium on High Energy Physics with Polarized Beams and Polarized Targets. The programme was densely packed, covering physics interests with spin as well as the accelerator and target techniques which make spin physics possible.

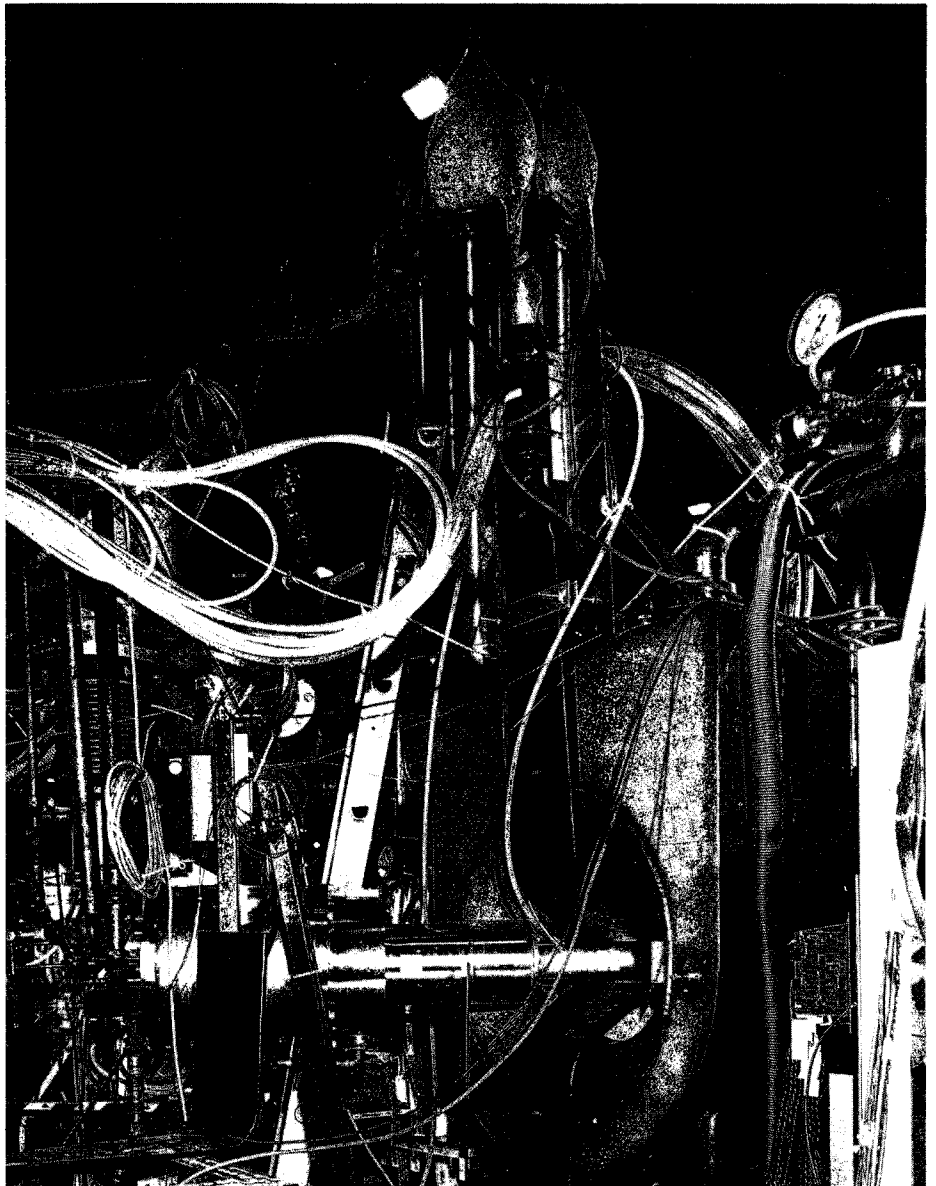
The physics

While major physics conferences these days are dominated by the promise of the 'new orthodoxy'—standard electroweak theory plus quantum chromodynamics providing a basis for the understanding of all basic interactions (except gravity) in terms of quark-lepton interactions—this was far from being the case at Lausanne.

Spin physics has given indications of new phenomena which are not readily explained in terms of existing ideas. Using high energy non-polarized proton beams on non-polarized nuclear targets, the polarization of the produced lambda hyperons shows that spin is not just a detail confined to low energy interactions.

At Lausanne, Oliver Overseth presented latest polarization results from the long-standing Michigan/Minnesota/Rutgers/Wisconsin collaboration at Fermilab. This now provides polarization measurements of charged, as well as neutral hyperons, and preliminary data shows that the polarization of positively-charged sigma particles is opposite to that of the lambda and cascade particles.

Any hyperon polarization is puzzling if it is assumed that 400 GeV proton-nucleus collisions must be so complex that any spin effects are averaged out. However Overseth turns this argument around: if polarization is observed in these reac-



tions, then something simple must be happening!

These hyperon results are supported by data at other energies from Brookhaven, the CERN ISR and Serpukhov. One promising suggestion is that the hyperon polarization comes directly from the strange quarks picked up from the sea of virtual quark-antiquark pairs surrounding the target nucleons. This sea is itself unpolarized, but candi-

date mechanisms have been proposed which could explain why single quarks coming from this sea would have a definite spin state.

The same Fermilab experimental programme has provided indications of hyperon magnetic moments. Final results, covering a wider range of hyperons, are still awaited, but the data amassed so far at Fermilab and from other experiments (such as the HYBUC bubble chamber at CERN)

give results which are not easily explained in terms of any conventional quark model.

More unexplained results come from spin studies using polarized beams and/or polarized targets, such as those carried out at the Argonne ZGS before its closure last year. (There was a lot of discussion on the possibility of continuing this valuable work at Argonne at other machines and at higher energies.) Another open book is the spectroscopy of dibaryon resonances, reported at Lausanne from a number of different experiments. With all this evidence, specialists are adamant that spin is an essential consideration, important in all energy regimes.

Quantum chromodynamics, handcuffed to perturbation theory, has had little to say about the kinematical areas where these spin effects occur and about spin in general, although at Lausanne Stanley Brodsky of SLAC proposed how the spin of quark and gluon interactions could lead to selection rules.

The Lausanne meeting contained its own mini-conference—a roundtable discussion initially entitled 'Is spin physics worthwhile?'—with theory, experiment and machine specialists taking part. However the participants were so convinced that spin physics is worthwhile that the first resolution was to change the title of the discussion.

The ensuing physics discussion soon turned to the merits of quantum chromodynamics as a serious theory of strong interactions. Elliott Leader challenged his fellow theorists to propose the 'cleanest' tests of QCD. This invitation was directly taken up by Stan Brodsky who was of the view that QCD predictions for certain exclusive channels were extremely clean, and that if these predictions turned out to be wrong,

he for one was ready to give up QCD.

As well as the effects seen in hadron experiments, there is now a lot of interest in the physics that can be done using polarized electron beams. The major results obtained at SLAC on polarization effects in deep inelastic scattering showed up the delicate interference between weak and electromagnetic interactions, and could be the herald of a new type of physics experiment. The discussions at Lausanne mirrored this growing interest in polarized electron beams and the experiments which could be done with them at new machines such as LEP and HERA.

The Lausanne meeting provided a very welcome opportunity for spin specialists to meet and exchange views. It was easy to get the impression that it also gave them a chance to vent some of their frustrations. Although some unexplained spin effects are now several years old, some people were of the view that the message is not getting across. As it has been voiced in high (energy) circles recently when referring to some of these recent spin results—'to believe that high energy physics is now understood is just plain foolish!'

The technology

The provision of the necessary experimental conditions to study high energy spin physics began with the work on polarized targets which became feasible following development of the dynamic polarization method in the early 60s and mastery of the technologies of high magnetic fields and low temperatures. The ideas came from A. Abragam at Saclay and were first pursued there and at the Berkeley Laboratory under C.D. Jefferies.

The present state of the art was reviewed at the Symposium by T.O. Niinikoski, a specialist in the use of extremely low temperatures in polarized targets at CERN, where polarized target research had been led for many years by M. Borghini. Among the new polarizable materials which hold out the promise of higher polarization (and/or have more easily polarizable nuclei) are lithium deuteride, pursued particularly at Saclay, where polarizations of over 70 per cent have been achieved, and ammonia, with which 90 per cent polarization has been achieved, used at Bonn, Stanford and CERN. The techniques of frozen spin targets, where the target material can be polarized and then transferred, retaining its polarization, to a location providing greater detector access, seem to be well mastered.

Performance of polarized sources has also advanced steadily. Polarized negative hydrogen ions (reviewed by W. Haeberli) are of particular interest for multiturn injection in proton accelerators. The technique using atomic beams is under development, for example, at Bonn, Dubna, Zurich and Argonne (for use at the Brookhaven AGS following closure of the ZGS) and is yielding negative ion beams of several μA . The ionization method developed at CERN, in collaboration with ANAC of New Zealand (achieving the record current of 110 μA of polarized protons) is being applied successfully at Zurich to negative ions. A new method, proposed by Haeberli, where polarized neutral atoms collect an electron on passing through a paramagnetic vapour such as sodium, is also giving promising results at Wisconsin and at KEK, Japan.

A team at CERN, with the assistance of a Lausanne / Michigan / Rockefeller collaboration, has fastened onto the atomic beam polar-

Polarization in electron rings

One of the main talking points at the Lausanne Symposium was the likelihood of achieving polarization in electron rings at high energy. The realization that synchrotron radiation could result in polarization in an electron storage ring came from A.A. Sokolov and I.M. Ternov in 1964. Experiments were proposed on SPEAR in 1971, following reports of polarization measurements from Orsay and Novosibirsk, and large polarization

effects were recorded two years later. Since 1973, Stanford has also pursued the polarization monitoring technique by backscattering of a laser beam, proposed by D. Fryberger and D. Prescott (the technique had earlier been suggested by V.N. Baier and V. Khoze in the Soviet Union). The laser polarimeter was operated on SPEAR in 1977 and a version for the PEP storage ring is now under construction.

ized proton source configuration to propose a polarized jet target as an internal target for an accelerator providing a density of over 10^{12} atoms per cm^3 (reported by W. Kubischta). L. Dick, in discussing the physics which would be possible with such a target, talked of future plans for a very high density target (over 10^{15} atoms per cm^3) which could allow measurements with precision of 10^{-7} and make it possible to see such refined effects as the neutral current interference with the strong interaction. A new range of polarization physics with high precision will also be possible on the LEAR storage ring at CERN (reported by K. Kilian), given the high intensities of the low energy antiproton beams.

Polarized electron sources have been a speciality at Stanford, where a Yale team installed the first source, known as PEGGY, in 1974. The latest work, led by Charlie Sinclair, has achieved emission currents of 60 A from a gallium arsenide photocathode. Typical emerging beams at 120 Hz have 40 per cent polarization and 0.5 A currents. Improvements are being sought with gallium

aluminium arsenide cathodes and other semiconductor materials. Charlie Prescott covered the interest in polarized beam physics with the proposed Single Pass Collider at SLAC.

It is particularly in the area of polarized beams in accelerators and storage rings that a great deal of new information and interest has welled up in recent years. This was reflected at the Symposium by the presence in force, for the first time at one of these polarization meetings, of leading accelerator physicists.

Polarized proton beams in accelerators were covered recently in the CERN COURIER (see May issue, page 104), but in passing them by it is still worth acknowledging the achievement of GeV range polarized beams at the Argonne Zero Gradient Synchrotron. It was an Argonne / Michigan / CERN group who first pushed this work theoretically and experimentally from 1974. There was interest at that time in polarized beams in the CERN PS, but this development was halted to give priority to other projects. Argonne thus carried the polarization flag

alone and, with the closure of the ZGS, it has now been passed to Brookhaven, KEK and Fermilab.

While Argonne pushed polarized protons, polarized electrons were investigated mainly by Stanford, using the SPEAR storage ring. The main concern now is whether polarization will be retained in the higher energy machines. A full review of the problem was given by J. Buon. The happy news from the PETRA storage ring at DESY (see July/August issue, page 196) was reported by R. Rossmanith. While polarization is seen with a single beam, it is absent with two beams, so it is obvious that some beam-beam conditions spoil the polarization. The hunt for stable polarization colliding beam conditions will be pursued. Alex Chao, leaning on the experience with SPEAR, showed the calculated conditions in which polarization is expected in PEP. Looking further into the future, Bryan Montague has been studying the problems of retaining polarized beams in LEP and of spin rotation in the colliding beam regions.

The accelerator physics behind these calculations on the degree of polarization which can be attained led to much discussion at the Symposium. A favourite candidate to help retain polarization is the Siberian Snake, a magnetic field inversion technique so-called because it was invented at Novosibirsk. The full extent of its abilities requires further detailed study, but it is already clear that two Snakes would be needed in an electron storage ring.

Covering a wide and ambitious programme, the interdisciplinary aspect of the Lausanne meeting was striking, and it was stimulating to see the high level of interaction between particle physicists, condensed matter specialists and the accelerator fraternity.