

mass energy (TeV range), but one providing luminosity around 10^{32} per cm^2 per s. It must be a linear machine to avoid the burden of energy loss by synchrotron radiation. The Workshop therefore concentrated on new technologies which might open up the possibility of much higher energy electron-positron colliders at significantly reduced cost. To get the high luminosity, beam focusing will need to be stronger than used up to now and ability to handle sub-micron size beams has not yet been demonstrated. However Stanford will be confronting a comparable challenge in a few years' time at the SLAC Linear Collider.

The interrelation between the various parameters that can be specified for such a machine is quite well understood and a list of needs, in order to achieve much higher energies with good luminosities, can therefore be written down. They include better quality particle sources, ways to sustain beam quality, much better efficiencies in converting power 'from the wall plug' to power in the beam, higher accelerating fields... The last of these requirements has been receiving most attention so far in the search for new techniques but, somewhere along the line, the others will need serious attention also.

At the Workshop, the techniques were considered under several headings. 'Near field' devices include improvements to the conventional linac where work is underway for example at Stanford and Novosibirsk. There is particular interest (to push up the accelerating fields beyond the 100 MeV per m already achieved) in greatly improved power sources. An interesting development has emerged in a project for 1 TeV colliding linacs which has wide participation from institutes in Japan. They are working on a new type of r. f.

power source called a lasertron aiming for 10 GW.

Other near field schemes are two-beam accelerators (under study at Berkeley) and wake field accelerators (DESY). They both act as transformers taking energy from a comparatively low energy, high current beam and passing it to what becomes a low current, high energy beam. Several structures for two-beam schemes are being developed and a wake field structure should be ready for tests next year. A new idea in this category comes from Bob Palmer at Brookhaven who has imagined beam passing through a structure made of spray droplets 'plasma-fied' by laser radiation. Tests with arrays of synchronized jets showed remarkable droplet positional regularity but, as one participant elegantly put it, 'the technique is fraught with potential difficulties'.

'Far field' devices, such as the inverse free electron laser, do not seem to have gone far. It looks as if synchrotron radiation effects kill these ideas.

'Media' devices were the ones that stirred up most excitement at the Oxford meeting and that excitement is still alive. The essence of the scheme is to beat two laser waves together, creating very high accelerating fields in a plasma. The production of such beat waves has been demonstrated as has the feasibility of some particle acceleration. Many centres are involved in theoretical and experimental work and, though there are clearly many problems ahead, nothing has been encountered so far to damp the high enthusiasm.

It was impressive at the Workshop to see the rate at which interest in new acceleration techniques has taken hold. In the two years since the realization became strong that conventional accelerators are hitting up

against the stops, a lot of thinking has gone into the subject. At Frascati it was even more impressive to see that experimental checks on this thinking are also underway.

Local equilibrium

From 3-6 September the First International Workshop on Local Equilibrium in Strong Interaction Physics took place in Bad-Honnef at the Physics Centre of the German Physical Society.

There are common phenomena and methods in different energy regimes of strong interaction physics (nuclear and particle physics) which are intimately linked with local equilibrium, a concept familiar in macroscopic physics, but less popular in microscopic physics. The simplest example from everyday life is a system in which the temperature is non-uniform. Such a situation is however also met in nuclear and particle physics in the phenomenon of 'hot spots' (see March 1979 issue, page 24). But local equilibrium has a much wider range of applications. Thus such topics of high current interest as phase transitions and quark-gluon plasma, as well as the applicability of hydrodynamical and statistical methods in general, which are so useful when the number of particles and degrees of freedom are large, as is the case in strong interaction physics, are difficult to conceive without the existence of local equilibrium.

That is probably the reason that this workshop, convened by D. K. Scott (Michigan) and R. M. Weiner (Marburg) could attract so many leading experts from all over the world.

A number of talks covered the experimental and theoretical investigation of the 'hot spots' effect, both in high energy particle physics and in

Some of the participants at the First International Workshop on Local Equilibrium in Strong Interaction Physics, which took place in September at Bad-Honnef, West Germany.



intermediate energy nuclear physics. In this last domain this effect has become one of the main tools of investigation, being used by some researchers even for 'applications', like the study of phase transitions. As a possible mechanism for the formation of hot spots in nuclear matter, solitons were suggested.

Great interest centred on the large fluctuations observed by the CERN UA5 experiment studying proton-antiproton collisions at 540 GeV collision energy in the number of produced secondaries in narrow (rapidity) intervals, which were reported by K. Böckmann (Bonn). The question whether these fluctuations are only of statistical nature or whether they are due to hot spots in quark-gluon plasma, as suggested by L. Van Hove (CERN), has yet to be answered. Similar fluctuations in proton-nucleus reactions at 300 GeV laboratory energy were reported for

the first time at this meeting by E. M. Friedlander (Berkeley).

The determination of sizes and lifetimes of sources (hot spots?) both in nuclear and particle physics was another topic of discussion. The method used for this determination is again inspired from macroscopic physics, being essentially equivalent to the interference method used for the measurement of radii of stars; the role of photons (light) is played in microscopic physics by mesons, nucleons or light nuclei. An important piece of evidence for 'hot spots' in nuclei at intermediate energies reported by Gelbke (Michigan) referred to the fact that the interference (two-body correlations) effect is observed only for the high energy protons, confirming thus that the emitting source is indeed 'hot'. Similar observations were reported earlier at higher energies in heavy ion collisions; the same interference method was

used to determine the freeze-out density of nuclear matter.

The analogy between astronomy and particle physics goes however much further. Light beams can be both coherent (laser-like) and chaotic (incoherent) and the same duality is expected to hold for mesonic fields, too. This may have important implications for our understanding of strong interaction dynamics, being possibly connected with the existence for example of gluon or quark-antiquark condensates in hadronic and pion condensates in nuclear matter.

The recent measurements in electron-positron reactions from DESY reported by P. Mättig and from SLAC reported by G. Goldhaber show strong evidence that a very large amount of coherence (over 90 per cent) characterizes the pion fields in these reactions. This evidence is now based on two independent experimental facts: the Bose-Einstein two-body correlations and the multiplicity distributions of secondaries.

As a point of historical interest it should be mentioned that the Bose-Einstein correlation effect discovered by G. Goldhaber, S. Goldhaber, Lee and Pais and known as the GGLP effect had its 25th anniversary at this workshop. G. Goldhaber's review talk (presented by P. Mättig) summarized the subject both in particle and heavy-ion physics.

The relationship between hadron production in electron-positron and hadron-hadron reactions in general was the subject of several talks. While Barshay (Aachen) treated this relationship from the point of view of the impact parameter, Plümer et al. (Marburg) introduced the inelasticity distribution as an alternative, which has the advantage that it is not dependent on geometric considerations and is directly accessible to measurements. This physical quanti-

ty has important implications in the interpretation of many-particle production processes, since it appears that these processes depend on the actual energy deposited into the system rather than the total available energy. This inelasticity, which is also related to the leading particle effect in hadronic interactions, can be determined event by event in hadronic interactions and related to the behaviour in electron-positron reactions at the appropriate energy.

One interesting application of the inelasticity distribution discussed at Bad-Honnef is a possible explanation of the correlation between the average transverse momentum of secondaries and the multiplicity within Landau's hydrodynamical model. This is a subject of high current interest since it may be connected with a phase transition to quark-gluon plasma. While so far this correlation was known only in proton-proton (ISR) and proton-anti-proton (CERN Collider) reactions, at Bad-Honnef, Mättig presented for the first time experimental results on this effect in electron-positron reactions.

The meeting, sponsored by the Deutsche Forschungsgemeinschaft, was a success. It certainly clarified several important problems connected with local equilibrium in strong interaction physics and brought up new results and viewpoints. The proceedings are being published by World Scientific.

(From Richard Weiner)

Muon-catalyzed fusion revisited

A negative muon can induce nuclear fusion in the reaction of deuteron and triton nuclei giving a helium nucleus,

a neutron and an emerging negative muon. The muon forms a tightly-bound deuteron-triton-muon molecule and fusion follows in about 10^{-12} s. Then the muon is free again to induce further reactions. Thus the muon can serve as a catalyst for nuclear fusion, which can proceed without the need for the high temperatures which are needed in the confinement and inertial fusion schemes. At room temperature, up to 80 fusions per muon have recently been observed at the LAMPF machine at Los Alamos, and it is clear that this number can be exceeded. These and other results were presented at a summer Workshop on Muon-Catalyzed Fusion held in Jackson, Wyoming. Approximately fifty scientists attended from Austria, Canada, India, Italy, Japan, South Africa, West Germany, and the United States. The Workshop itself is symbolic of the revival of interest in this subject.

Muon-catalyzed (proton-deuteron) fusion was first observed in 1956 by Luis Alvarez and colleagues in hydrogen bubble chamber experiments at Berkeley, but the effect had been predicted as early as 1948 by F. C. Frank and A. D. Sakharov. Following a brief flurry of interest in the mid-50s, interest waned following predictions of, at most, only a few fusion cycles during the muon lifetime.

Muon catalysis has received renewed attention during the past six years or so primarily because of the work of the Soviet theorist L. I. Ponomarev and his colleagues, who have developed a model of resonant formation of the muon molecules. In this model, a small neutral triton-muon atom can penetrate a D_2 or DT molecule and then link with a deuteron to form a deuteron-triton-muon molecular ion without breaking up the electronic host molecule. The ion

serves as one of the nuclear centres of the electronic molecule. The energy released as the ion forms must be absorbed by the vibration and rotation of the electronic molecular complex. This muon-molecular formation process depends on the existence of a very loosely bound excited state of the molecule. Observations of very rapid molecular formation rates (about 10^9 per s) and pronounced dependence of that rate on the temperature of the deuteron-triton mixture lend strong support to this exotic model.

The field is now burgeoning with experiments at Dubna, Gatchina, Los Alamos, Vancouver, and Zurich. Efficient means of producing muons in a dedicated facility are being discussed (for example, using radio-frequency quadrupole pre-accelerators and neutron-rich projectiles and targets). Based on recent developments, several participants of the Workshop broached the subject of power production by means of muon-catalyzed fusion. Evidently, this long-standing dream of high energy physicists will be re-examined.

Further information on the Workshop can be obtained from the organizer, Steven Jones, Idaho National Engineering Lab., P.O. Box 1625, Idaho Falls, ID 83415.

Shower Simulation

A three-day meeting on the Simulation of Hadronic and Electromagnetic Showers will be held in the CERN Council Chamber beginning on Tuesday 29 January 1985.