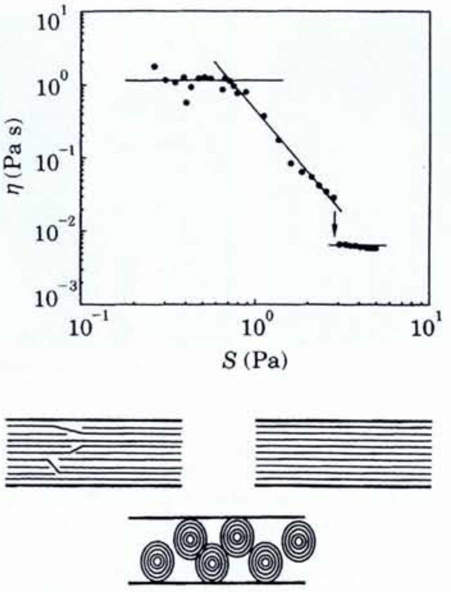

Fig. 3 — The viscosity of a sodium dodecyl sulphate-pentanol-dodecane-water mixture (71% of oil volume fraction). Multilayer vesicles (onion phase) form at intermediate shear rates S and the viscosity decreases rapidly as S increases (shear thinning). The layers (with and without dislocations: shown in the lower part) are parallel to the shear plates in the horizontal regions. [From Roux D. et al., Europhys. Lett. ***24** (1993) 53.]*

W. Helfich (Free Univ., Berlin) remarked in introducing the symposium on *Fluid Surfaces* that they are highly deformable 2-d objects in 3-d space found throughout nature as well as having important technical applications. Understanding their shapes, while mathematically challenging, is needed in order to analyze processes whereby vesicles (closed surfaces) fuse or form buds (small outgrowths). A lipid bilayer (a surfactant monolayer with oil or water on both sides) is particularly easy to work with since it does not crumple easily (high rigidity). **R. Lipowsky** (KFA, Jülich) explained that a theory has been developed based on the bending energy as a function of local curvature subject to volume and surface area constraints which predicts, for the simple case of spherical topology and axial symmetry, a large number of possible shapes depending on the reduced total area and the reduced volume. For toroidal topology, conformal transformations predict a large region in the area/volume phase diagram with axisymmetric shapes where the ground state is degenerate. Interesting things happen when a second hole is introduced into the torus, notably diffusion between shapes which, if observed, would be proof of conformal transformation. A simple way to monitor shape changes is to introduce a line discontinuity in a film. For a circular domain in a 2-d membrane, the domain forms a bud when it reaches a certain size in order to reduce the edge energy (Fig. 2); the same process can be modelled in spherical vesicles. It is believed that similar results apply in complex biomembranes where budding has been observed, but experiments are difficult.

M.E. Cates (Cambridge) invoked the bending energy model used for lipid bilayers to discuss bilayer aggregates made from surfactants. Since bending takes place over 10-100 nm rather than 100 μm, entropy effects mean that structures with a higher energy may be stable. Various phases (sponge, vesicle, onion) arise on tuning the rigidity by varying the alcohol/surfactant ratio in a alcohol-surfactant-water mixture, but he concentrated on the latter two. Huge (radius r = 5-20 m), stable multilayer vesicles can form (spontaneously or on shearing); the onion phase developed when the multilayer vesicles contact at high volume fractions is a viscoelastic solid (*i.e.*, it yields) having important potential applications as a stable, highly organic material. Among the many intriguing questions concerning mechanical and rheological properties (Fig. 3), there has been some success recently in confirming the prediction that the elastic modulus of the onion phase is proportional to $1/r$; whether it behaves like a glass with frozen disorder at large r remains unclear.

The $C_{12}E_5$-alcohol-water system remains one of the most popular for investigating the many different structures formed by fluid surfaces. **U. Olsson** (Lund) showed how understanding is based upon the "channels" and other features appearing in phase diagrams which are analyzed in terms of the diffusion of the various components in the mixtures.

The Editor wishes to thank A. Aspect, J.T. Devreese, F. Dalfovo and for their contributions.

EUROPHYSICS INTERNATIONAL HIGH ENERGY PHYSICS CONFERENCE
(Marseilles, 21-28 July 1993)

Issues Brought into Sharper Focus

A report taken from the EPS-9 plenary lecture entitled "The Quest for the Infitesimally Small" by C. Rubbia.

Some 40 years ago one could only probe down to 10^{-15} m and the proton was an elementary particle. Today, the success of colliders such as CERN's LEP and of the Standard Model (SM) with its fundamental interactions and 24 fundamental fermions (and their antiparticles) allows precision probing at the 10^{-18} m scale. Although the Standard Model works well, one cannot be completely satisfied. We need to understand the nature of symmetry breaking which is introduced and in doing so we shall hopefully be able to predict or relate some off the model's many parameters.

The main questions are associated with the structure of the vacuum for the SM is built on gauge theory that invokes the so-called Higgs mechanism to provide particles with masses while keeping the theory renormalisable. The mechanism is seen as involving a vacuum containing a field where fluctuations from a non-zero expectation value correspond to the presence of a neutral spin-zero particle (the Higgs meson). The temperature at which the vacuum returns to normal (and the masses of the W and Z particles disappear) is estimated to be of the order of 200 GeV. Dramatic new features are expected at energies well above this critical temperature for the weak interaction. An energy of the order of 1 TeV at the quark-gluon level is needed so the energy scale of future colliders is clear. In spite of some limitations, circular pp-machines such as CERN's proposed LHC and the discontinued SSC are preferred because one knows how to build them.

Looking beyond the SM, the similarity between the two coupling constants for the electroweak theory and the constant for the strong force, and the fact that all three converge with increasing energy, suggest they will meet (at 10^{16} GeV according to the latest LEP data). A Grand Unified Theory then takes over and quarks and leptons appear as different manifestations of the same field. The main question is the form that GUT should take. One would like to incorporate the SM into some GUT. Superstrings at much higher energies (the Planck scale at 10^{19} GeV) have guided thinking for over a decade (in superstring theory, fundamental fields appear as the many lowest excitation modes of a superstring visualised as a tiny loop closed upon itself, probably in more than three directions in space). What one has not succeeded to do is to extract from such a "theory of everything" compelling restraints which would apply to today's experimental domain at 10^2 GeV. Secondly, GUT mixes quarks and leptons so it implies proton decay which should be sought for as it is the only way we have to test the theory. The present limit of 10^{32} years relates to a particular decay mode: it is vital to push this limit and to look for other modes using more sophisticated detectors. Instead of increasing the energy of particle colliders, the approach here involves probing smaller scales through virtual reactions (*i.e.*, analyzing very carefully the rare processes implied in jumping large energy barriers). Recent results for double-decay where one seeks evidence for a direct route without the production of a neutrino illustrates the level of sensitivity that can be achieved.

Success Means Questions

The remarkably successful SM is therefore not the end of the road but is providing starting points for exciting new ventures. It is also raising challenging problems. One of the actors is still missing (the top quark); non-observation implies a mass greater than 108 GeV so the 2000 GeV pp-collider at Fermilab in the USA is the only place one can hope to find it. Fermilab reports "a number of interesting events", identification being difficult owing to the small cross-section, rapid decay, and a high background level. However, LEP data are now so accurate that one can extract values of the radiative corrections and compare them with theoretical estimates to obtain the mass of the top. The result is 160 ± 16 GeV which is similar to the value one infers from the number of Fermilab events if they are taken as top mediated, so the top seems to be around the corner.

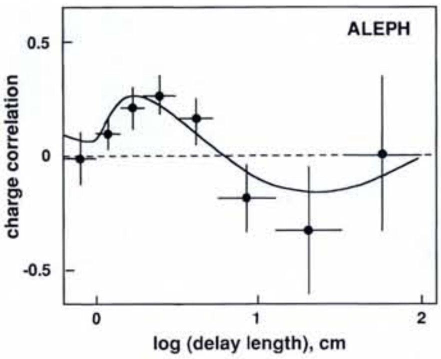

Fig. 1 — B-$\bar{B}$ oscillations as measured at LEP: the D-lepton charge correlation is plotted as a function of decay length. The curve shows the results of a calculated fit allowing for oscillations.*

Continuing with the electroweak corrections at LEP, if the top is taken into account there is very little room for other radiative effects which could reveal new physics through its virtual effects. It is not known why there is this "conspiracy" to make the corrections cancel when each one is sizable so this may be a signal of something significant. In any event, the top quark has to be far more massive than the W or Z for the conspiracy to happen.

The electroweak interaction mixes quarks of different families according to a mixing matrix connecting lower charged members to higher charged ones. Constraints on the matrix allow a small cp-violation which is badly needed to build an excess of particles over antiparticles in the exploding early Universe. However, confirmation by measuring mixing parameters for neutral kaon decay (which remains the only system known to show cp-violation) remains inconclusive. It is therefore important to continue to measure the parameters, in spite of the fact that they are very small for mixing between different quark families. A major new impetus was provided this summer by the first report of a new type of b-s transition seen in BK decay. One can also now monitor the neutral B-meson oscillation (Fig. 1; equivalent to the famous K-$\bar{K}$ oscillation in neutral kaon decay) so the neutral B system is turning out to be a beautiful tool. The feeling that this system will eventually offer another window on cp-violation has motivated proposals to build B-factories delivering many B mesons under well-controlled conditions. A 200 $US project at SLAC in California for completion in 1998 was approved in October (in spite of a scientific evaluation reporting in the summer that a Cornell proposal, although riskier, was cheaper). Japan has proposed a similar project, and interest is growing in tapping the B's produced at present and future pp-colliders.

Neutrinos to the Fore

Neutrinos however probably represent the most exciting sector of the lepton world. In the SM they are massless, left-handed and cannot mix amongst themselves. Cosmological constraints indicate that a neutrino mass of 20-30 eV would be enough to make the Universe critical, hence interest in the masses. Moreover, a non-zero mass would represent a departure from the SM. Experimental limits are now much smaller than the lepton and quark masses in the same family, the recent debate about a possible 17 keV tau-neutrino having been settled this summer. If neutrinos have mass they would probably mix (when neutrinos of one species turn into another, and *vice versa*) and this has become a topic of extensive study that was discussed by several speakers at the EPS-9 General Conference.

Hadron Physics Taking Off

Hadron physics, now very much the meeting place of nuclear and particle physicists, continues to have difficulty to use quantum chromodynamics (QCD), clearly the correct theory for strong interactions, to reproduce hadron properties and hadronic interactions. Accurate calculations are possible on applying QCD perturbatively at large momentum transfers (small distances). At larger distances when the quarks are confined even the fastest computers are inadequate and one is left with semi-quantitative agreement at best. Experimental clues for confinement are sought, with spectroscopists at CERN's antiproton ring LEAR hunting for unusual states, and heavy-ion programmes looking for the quark-gluon plasma ("colour" de-confinement). Evidence for specific predicted features of plasma formation (*e.g.*, J/ψ suppression, strangeness enhancement) is not strong enough for firm conclusions, hence the importance of a new heavy-ion source (Pb) under construction at CERN and completion of the RHIC collider in the USA by the end of the decade.

Deep inelastic scattering can test the hadron structure as described by QCD by determining how the quark and gluon distributions vary with increasing momentum transfer Q. Studies received an enormous boost with the start-up in 1992 of the first electron-proton collider ever built (HERA at DESY) giving hundred-fold extensions to the ranges of the main variables (Q^2 and a dimensionless variable x). Using only 1/40000 of the design luminosity (which is being approached very quickly), the so-called structure functions of Q^2 for different x are in good agreement with previous data. A sharp rise at low x was found (Fig. 2) in agreement with some theories (the quarks and gluons are branching into many quarks, antiquarks and gluons) and it will be interesting to see the screening these constituents will have on one another as they become more numerous. At large cross-sections, such as those for photoproduction, HERA has looked at 210 GeV when little was known beyond 20 GeV and found total photoproduction cross-sections agreeing with predicted values. There have been other interesting findings so a detailed look at the inside of the proton is clearly around the corner.

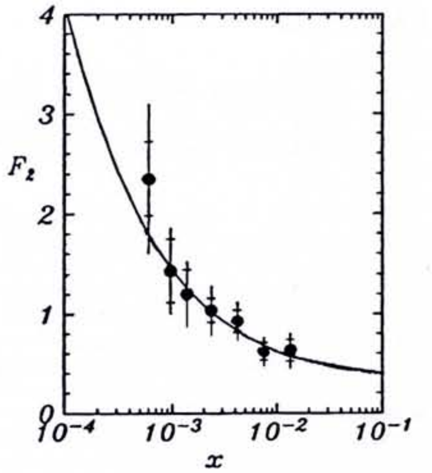

Fig. 2 — Hadronic physics at low-x: the predicted sharp rise of the structure function F_2 is observed (H1 detector at HERA; Q^2 = 30 GeV^2). [Bernardi et al.*, 1993.]*

Call for Candidates

In the framework of the European Programme "Human Capital and Mobility", the network "Non-Classical Light" proposes post-doctoral positions in the following laboratories. The nominal duration of the positions is six months for each laboratory, but a one-year position can be negotiated, involving joint work between two laboratories.

The general subject of the research are experimental and/or theoretical studies (depending on the laboratory involved) of the interaction of matter and radiation, at a level where the specific quantum properties of the electromagnetic field play a major role. Examples are non-linear optics with atoms, crystals or semi-conductors for achieving quantum noise reduction, cavity QED, quantum light propagation and interaction with matter...

1. Institut d'Optique (Orsay, France): Dr. P. Grangier (coordinator)
2. University of Leiden (The Netherlands): Prof. J.P. Woerdman
3. Essex University (UK): Prof. R. Loudon
4. Strathclyde University (UK): Prof. S. Barnett
5. University of Belfast (UK): Prof. S. Swain
6. Lab. de Spectroscopie Hertzienne (Paris, France): Dr. E. Giacobino
7. Lab. de Spectroscopie Hertzienne (Paris, France): Prof. J.M. Raimond
8. Imperial College (London, UK): Prof. P. Knight
9. University of Constance (Germany): Prof. J. Mlynek
10. University of Ulm (Germany): Prof. W. Schleich
11. Max-Planck-Institut für Quantenoptik (Garching, Germany): Prof. H. Walther
12. University of Milano (Italy): Prof. L. Lugiato
13. University of Camerino (Italy): Prof. P. Tombesi
14. University of the Baleares (Spain): Prof. San Miguel
15. Inst. de Estructura de la Materia, CSIC (Madrid, Spain): Dr. Garcia-Fernandez
16. University of Innsbruck (Austria): Prof. A. Zeilinger

Candidates should send a short *curriculum vitae*, a list of publications, and a letter explaining their motivations and interests to the following address:

Mrs Nelly Bonavent, Institut d'Optique, B.P. 147, F-91403 Orsay Cedex.

The deadlines for application to the network occur about three weeks before the EC deadlines for the approval of selected candidates. The next network deadline is therefore **January 12, 1994 in Orsay**. This call will remain open until all positions are filled.