Midterm Review Report

TMR Network Title	:	EURODAPHNE
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Date and timing of meeting	:	September 29th, 2000 10:30-19:00
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TMR NETWORK

EURODAPHNE

High Precision Elementary Particle Physics at the Φ-factory DAΦNE

EU contract no.: ERBFMRXCT98-0169

Midterm Report 04/1998 - 09/2000

A - Research Results

A.1 Scientific Highlights

The ultimate goal of the EURODAPHNE project is to deepen the understanding and predictability of the Standard Model of Elementary Particles in the low energy region which is being explored by the DAΦNE accelerator, in operation in Frascati, but also by a number of other machines in the world. Our research program focusses on 6 major issues, in each one of which our network has substantially contributed to change the state-of-the-art. In the following, the main scientific highlights reached in each of them will be outlined.

The Origin of CP violation

CP violation was discovered more than 30 years ago, but its origin is still obscure. It is still unknown whether there exists or not a contribution from outside the Standard Model and the understanding of this puzzle may shed light on the origin of our universe. During the operation of our network, remarkable progress has been achieved towards the formulation of better theoretical tools to study this problem. By far the majority of these improvements has been obtained by members of this network.

Let us examine them, in detail.

New estimates of ϵ'/ϵ within the Standard Model: Important results have been obtained in the theoretical predictions for the CP-violation parameters ϵ'/ϵ, whose value can shed ligth on Physics beyond the Standard Model. A new analysis of $K \to 2\pi$ decays, and in particular of the direct-CP-violating parameter ϵ'/ϵ, has been performed employing an improved approach based on the $1/N_c$ expansion. A big effort has also been devoted to improve the evaluation of the strong enhancement provided by final state interactions. These results are in good agreement with the recent experimental measurements, clarifying the previous discrepancies in the literature.

Supersymmetric effects in CP-violating observables and rare K decays: A systematic analysis of CP-violating observables and rare K decays has been performed within supersymmetric extensions of the Standard Model with generic flavour couplings. It has been shown, in particular, that ϵ'/ϵ could receive sizable supersymmetric contributions, whose non-standard nature could be clearly identified by means of the rare decays $K_L \to \pi^0 e^+ e^- (\nu\bar{\nu})$. The correlations between ϵ'/ϵ and the CP-violating observables in $K \to \pi\pi\gamma$ and $K \to 3\pi$ decays have been analyzed.

Analytic evaluation of the decay modes: $\pi \to e^+e^-$ and $\eta \to \mu^+\mu^-$ within the large–N_c QCD framework. This is a free parameter calculation, and the results obtained compare well with the experimental results. At the technical level, it involves the evaluation of a three–point function, and therefore it is one step forward towards our program of getting the full $\Delta S = 1$ and $\Delta S = 2$ amplitudes in K–decays and a controlled analytic evaluation of ϵ'/ϵ in the Standard Model.

CP-violation and nonleptonic matrix-elements: The Lund-Granada collaboration has made significant progress on understanding the value of ϵ'/ϵ, as well as on the value of ϵ and on the general issue of understanding the pattern of $K \to \pi\pi$ decays. In this context we solved several problems that have affected all earlier calculations: the problem of connecting in a consistent manner low-energy calculations with QCD was solved and the solution to the scheme-dependence problem was presented. The final result for all quantities is in excellent agreement with all observables within the present uncertainties.

Isospin violating contributions ϵ'/ϵ : In a joint project between three nodes, the isospin-violating contribution due to $\pi^0 - \eta$ mixing was investigated in a systematic low-energy expansion. It was shown that the big contribution of $\eta - \eta'$ mixing is largely canceled by other contributions occurring at the same chiral order that had not been included before. This result has already been used frequently in theoretical analyses of ϵ'/ϵ.

B-decays: New methods have been elaborated of extracting CKM- matrix elements and/or CP-violation parameters from various B-decays: sequential decays $B \to hyperon + antihyperon$, inclusive decays $B \to D_s + X_u$, semileptonic transitions $B \to \pi$ and $B \to \rho$, Dalitz plot of the decay $B \to 3\pi$.

Chiral Perturbation Theory

Chiral Perturbation Theory (ChPT or χPT) is a systematic method developed to analyze the low-energy structure of the Standard Model and to describe particle interactions in the low-energy domain, where the tools of Perturbative Quantum Chromodynamics are inadequate. This method owes its modern formulation to members of our network and its refinement and improvement are one of our main research endeavours. Very remarkable progress has been obtained during the first two years of operation of this network, which includes all european leaders in the field. We shall here describe some of the main advances.

The Roy equations for the lowest partial waves of elastic $\pi\pi$ scattering have been analyzed. It has been demonstrated that the two S-wave scattering lengths a_0^0 and a_0^2 are the essential parameters in the low energy region: Once these are known, the available experimental information determines the behaviour near threshold to within remarkably small uncertainties. An explicit numerical representation for the energy dependence of the S- and P-waves has been given and it has been shown that the threshold parameters of the D- and F-waves are also fixed very sharply in terms of a_0^0 and a_0^2. Furthermore, the relevance of the decay $K \to \pi\,\pi\,e\,\nu$ in restricting the allowed range of a_0^0 has been highlighted, preparing the grounds for an analysis of the forthcoming precision data on this decay and on pionic atoms. It is expected that these reduce the uncertainties in the two basic low energy parameters very substantially, so that a meaningful test of the chiral perturbation theory predictions will become possible.

The known chiral perturbation theory representation of the $\pi\pi$ scattering amplitude to two loops has been matched to the phenomenological description. The resulting predictions, $a_0^0 = 0.220 \pm 0.005$, $a_0^2 = -0.0444 \pm 0.0010$, contain remarkably small uncertainties and thus allow a very sensitive experimental test of the hypothesis that the quark condensate is the leading order parameter of the spontaneously broken chiral symmetry.

Chiral Perturbation Theory at one loop has been used to analyze the general formula for the $\pi^+\pi^-$ atom lifetime derived earlier in the framework of QCD. The corresponding analytic expression has been investigated numerically, and compared with recent work in the literature.

The renormalization of the mesonic generating functional of $O(p^6)$ was performed in a joint project of Lund, Vienna and Zürich. This serves as a check for all existing and future two-loop calculations and it provides at the same time the leading infrared-singular pieces of Green functions, the chiral double logs. In addition, the effective chiral Lagrangian of $O(p^6)$ was constructed. The minimal number of independent monomials was given both for two and three light flavours, correcting and generalizing the published literature. The results of this project have been used in various applications, both by members of the EURODAPHNE collaboration and by others.

A new approach has been developed to obtain the rates of $K \to \pi\pi$ from lattice QCD simulations.

The N_f-dependence of chiral symmetry breaking has been identified. Vacuum fluctuations of $\bar{q}q$ suppress the quark condensate $\langle \bar{u}u \rangle$ as the number N_f of light fermion species in the sea increases. A chiral sum rule for the OZI-rule violating Low Energy Constant L_6 indicate a strong variation of the condensate between $N_f = 2$ and $N_f = 3$, due to observed properties of light scalar mesons ($f_0(980)$) and to the QCD control of higher energy contributions.

Low-energy $\pi - \pi$ scattering is directly related to the size of the $N_f = 2$ quark condensate. Nevertheless, it has been shown that a strong N_f-dependence of $\langle \bar{u}u \rangle$ due to a large violation of the OZI rule in the vacuum channel indirectly affects and modifies the prediction of standard χPT for s-wave scattering lengths.

The invariant $\hat{B}_K$ factor of K^0–$\bar{K^0}$ mixing in the chiral limit and to next–to–leading order in the $1/N_c$ expansion has been analytically evaluated. This is the first calculation which has succeeded to show the cancellation of the renormalization scale and scheme dependences between short– and long–distance contributions in the final expression. Numerical estimates have been obtained, by taking into account increasingly refined short– and long–distance constraints of the underlying QCD Green's function which governs the $\hat{B}_K$ factor.

Various aspects of weak-decay amplitudes for kaons have been worked in ChPT and in the $1/N_c$ expansion. Standard versus generalized ChPT has been discussed for the fusion of two photons into three pseudoscalars by a joint project among three nodes.

Interesting results have been obtained extending the Chiral Perturbation Theory description to the resonance region. A study of the hadronic off–shell width of meson resonances has been carried out, and a definition that is consistent with analyticiy, unitarity, chiral symmetry and the asymptotic behaviour ruled by QCD has been proposed. The Omnes resummation of infrared chiral logarithms has been used to obtain a remarkably good description of the vector and scalar pion form factors. Using a coupled–channel unitarity analysis a complete reanalysis of the $K\pi \to K\pi$ scattering data has been performed.

Isospin violation and electromagnetic corrections in nonleptonic K decays have been considered at next-to-leading order. The minimal form of the new chiral Lagrangian of $O(e^2G_Fp^2)$ was constructed and the renormalization was carried out. On the basis of these results, published calculations by another group had to be revised.

$\pi\pi$-scattering was calculated to two-loops in two-flavour ChPT and the pion scalar and vector form factors were also treated to the same accuracy. Excellent agreement with the available data was obtained. The theoretical structure was extended to two-loops by determining uniquely the structure of the effective action for any number of flavours and determining the number of unknown new constants and calculating the total divergence structure.

A systematical extension of the three flavour calculations to two-loop accuracy is under progress. This program has now calculated all decay constants, masses, vacuum expectation values and $K_{\ell 4}$ semi-leptonic decays to this accuracy. This allowed a consistent update of all parameters at two-loop order and sharpened the predictions for $\pi\pi$ scattering.

Chiral symmetry breaking: The effect of two-loop corrections on the pseudoscalar masses and quark condensates was calculated and studied. The effect of kaon-loops is substantial but not enough to invalidate the standard large condensate picture of CHPT. We used our calculation of the pion scalar form-factor to study the behaviour in the scalar sector at low energy finding no problem with the standard picture.

Vector Mesons: The understanding of chiral corrections in vector meson properties and how to treat it with effective lagrangians reached just before the actual start of the contract was extended to their decay constants. Contrary to the earlier case of the masses the chiral corrections here were more moderate.

Hadronic contribution to $g-2$: Our two-loop calculation of the pion vector form factor substantially improves the accuracy of the hadronic contribution to $g-2$ from energies below 500 MeV by allowing the use of the precise space-like data rather than the low precision direct data.

Quenched CHPT and connections with lattice QCD: We worked out how to extract the most possible information from well-defined two-particle quantities in order to obtain information on the physical $K \to \pi\pi$ decays.

Rare Decays of Pseudoscalar Mesons

A complete analysis of electromagnetic corrections for semileptonic decays of the light pseudoscalars requires an extension of the standard scheme of Chiral Perturbation Theory by including the photon and the light leptons as explicit degrees of freedom. The theoretical basis for such an extended low-energy effective theory has been worked out to the one-loop level. Super-heat-kernel methods were employed and a complete list of the relevant counterterms was given. As a first application, the decays $\pi(K) \to l\nu_l$ were discussed.

Next-to-leading order analysis of the rare decays $K \to \pi\ell^+\ell^-$ within CHPT has been performed. The long-distance contribution to the processes $K \to \pi\ell^+\ell^-$ has been analyzed beyond the leading order in CHPT. This analysis has allowed to obtain a precise prediction for the ratio $R = B(K^+ \to \pi^+\mu^+\mu^-)/B(K^+ \to \pi^+e^+e^-)$, that has recently been confirmed by BNL-E865 experiment. Similarly, a precise description of the dilepton-invariant-mass spectrum in $K^+ \to \pi^+e^+e^-$ has been obtained.

The Muon Anomaly

An improved determination of the total cross-section for the process $e^+e^- \rightarrow$ *hadrons* at low energies, is mandatory for high precision physics (e.g., indirect bounds on the Higgs mass, unraveling new physics effects) and is one of the major goals at the Daphne ϕ–factory. Such a measurement provides an important input for the determination of the hadronic contributions to the muon anomalous magnetic moment $(g-2)_\mu$ and the shift of the fine structure constant $\alpha_{\rm QED}(M_Z)$. Substantial progress has been made since the formulation of our work program in the following domains:

a) *Theoretically.*

Investigations of the validity of perturbative QCD towards low energy have led to a new approach – based on Euclidean Quantum Field Theory – which demonstrate that the data from DAΦNE can substantially improve not only our knowledge of the anomalous magnetic moment of the muon but also that of e.m. coupling constant.

b) *Phenomenologically.* There has been intense work to investigate the possibility of studying the cross-section by tuning the energy of the final hadronic state through emission of hard photons from the initial state (photon tagging), in view of the fact that DAΦNE will operate at a fixed energy corresponding to the ϕ-resonance and thus would not otherwise be able to contribute to the region of interest. The phenomenological studies showed the feasibility from the statistical and systematic point of view, by showing that the cross-section with a hard photon will be large enough to allow a reduction of the error, and that the background due to final state radiation can be kept under control by appropriate cuts.

c) *Monte Carlo techniques.*

Monte Carlo programs for the tagged photon scenario have been developed which implement the properties of the KLOE detector as it is mandatory for the analysis of the KLOE data. Data collected by KLOE have been analyzed and measurement and simulation show excellent agreement. Investigations of direct $\phi \rightarrow \pi^+\pi^-\gamma$ decay as a background for $e^+e^- \rightarrow \gamma +$ *hadrons* are well understood. Similarly a Monte Carlo program for the more difficult $2\pi^+2\pi^-$,$\pi^+\pi^-2\pi^0$ and $\omega\pi^0$ final states has been developed.

d) *Radiative corrections.*

Work necessary to obtain the required precision of the measurements is a major goal of the work program. These corrections have been implemented at order $O(\alpha)$ for the tagged photon case. Radiative corrections to $\pi^+\pi^-$ production including all mass effects have been recalculated and compared with previous results. It has been shown that as an alternative to the photon tagging method a fully inclusive measurement allows to control the $O(\alpha^2)$ initial state radiative corrections which turn out to be substantial. Cross checks with a standard complete two hard photon Monte Carlo provided important cross checks of the validity of recent calculations. The present status of radiative correction estimates goes substantially beyond previous calculations.

Meson Structure and the Enigma of Scalar Mesons

The place of scalar mesons in the spectrum of hadrons and their relation to the structure of QCD are still unanswered questions, but progress is being made, in particular by the joint work of this network. Studies have concentrated on the relative production mechanisms of these states in high energy central collisions, in J/ψ decays and in two photon reactions Progress in vector-meson decays and spectroscopy (as well as for scalar mesons) has been achieved. Some results on $\eta - \eta'$ physics –the role of the singlet in ChPT and the classical issue of $\eta - \eta'$ mixing– seem also to give a clear advance over present status.

We are close to a dynamical understanding of the radiative $\phi \to \gamma a_0, f_0$ amplitudes although the experimental information to compare with is still rather scarce and the elusive nature of the scalar resonances a_0 and f_0 further complicates the issue. Some insight into the dynamics of these two states have been gained and a theoretical assessment on scalar mesons should be reached near the end of the contract as scheduled.

The efforts by the Helsinki group to get the light sigma meson near 500-600 MeV accepted as a true resonance has born fruit. It is now supported by a rapidly growing number of authors, and especially at the meeting on the sigma meson in Kyoto in June.

Strange Particle and Nuclear Matter

The $\bar{K}N$ interaction has been studied within a chiral non-perturbative approach, both in free space and in the medium. The resulting $\bar{K}$ self-energy describes present data of kaonic atoms very satisfactorily and seems to rule out the phenomenon of kaon condensation in neutron stars. Implications on the medium modifications of the $\Lambda(1405)$ resonance (through photoproduction reactions or radiative scattering of K^- from nuclei) as well as the decay width of the Φ meson in nuclei have also been explored. Again, some of these results are above present day standards.

Chiral perturbation theory has been extended with a framework which implements unitarity in coupled channels and uses either expansions in the inverse of the T-matrix, or similar ones using the N/D method. This allows one to extend the realm of predictivity of the theory up to 1.2 GeV and reproduces all the mesonic resonances in that range, plus some low lying baryonic resonances, like the $\Lambda(1405)$ and the $N^*(1535)$. The work on baryonic resonances and the implications for K^-N scattering and K^- nucleus scattering has been done in collaboration with the Barcelona node. Applications of these new chiral unitary techniques have been done to a large number of reactions, like $\gamma\gamma \to meson - meson$, radiative $\phi \to \pi\pi\gamma$ and $\phi \to \pi\eta\gamma$ decays, vector and scalar form factors and processes of production of the $\Lambda(1405)$ resonance.

A2. Joint Publications

In the following, we list the joint publications which have been completed by two or more nodes of our network. Whenever a young researcher is one of the co-authors of a paper, his/her name is underlined.

We distinguish between papers published in refereed journals, papers published in Proceedings of Conferences, and we list, as the last, papers recently completed and posted in the international bulletin board at Los Alamos and submitted to a journal for publication.

The published papers have been grouped in six major categories, most of which correspond to the research highlights described in the previous section. Abstracts of all the papers published in refereed journals are appended to this report.

We have refrained from listing the joint publications in order of importance : the only semi-objective way to do this is through use of the impact parameter index, but it is the opinion of many members of this network that it is often unfair to recent papers and sometimes it also fails to do proper justice.

Published in refereed journals

CP Violation

1. G. D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, *The decays $K \to \pi\ell^+\ell^-$ beyond leading order in the chiral expansion*, J. High Energy Phys. **8**, 4 (1998)
   INFN-Valencia-Wien

2. G. Colangelo and G. Isidori, *Supersymmetric contributions to rare kaon decays: beyond the single mass insertion approximation*, J. High Energy Phys. **9**, 9 (1998)
   Bern-INFN

3. A.J. Buras, G. Colangelo, G. Isidori, A. Romanino and L. Silvestrini, *Connections between ε'/ε and rare kaon decays in supersymmetry*, Nucl. Phys. **B566**, 3 (2000)
   INFN-Zurich

4. E. Pallante and A. Pich, *Strong enhancement of ϵ'/ϵ through final state interactions*, Phys. Rev. Lett. **84**, 2568 (2000)
   Barcelona-Valencia

5. G. Ecker, G. G. Müller, H. Neufeld and A. Pich, π^0–η *Mixing and CP Violation*, Phys. Lett. **B477**, 88 (2000)
   Valencia-Wien

6. G. Colangelo, G. Isidori and J. Portoles, *Supersymmetric contributions to direct CP violation in $K \to \pi\pi\gamma$ decays*, Phys. Lett. **B470**, 134 (1999)
   INFN-Valencia-Zurich

7. J. Bijnens and J. Prades, $\varepsilon_K\prime/\varepsilon_K$ *in the Chiral Limit*, J. High Energy Phys. **6**, 35 (2000)
   Granada-Lund

8. M. Knecht, S. Peris and E. de Rafael, *Matrix Elements of Electroweak Penguin Operators in the $1/N_c$ Expansion*, Phys. Lett. **B457**, 227 (1999)
   Barcelona-Marseille

Chiral Perturbation Theory

9. G. D'Ambrosio and J. Portolés, *Spin–1 resonance contributions to the weak Chiral Lagrangian: the vector field formulation*, Nucl. Phys. **B533**, 494 (1998)
   INFN-Valencia

10. G. D'Ambrosio and J. Portolés, *Analysis of $K_L \to \pi^+\pi^-\gamma$ in Chiral Perturbation Theory*, Nucl. Phys. **B533**, 523 (1998)
    INFN-Valencia

11. S. Peris, M. Perrottet and E. de Rafael, *Matching Long and Short Distances in Large-N_c QCD*, J. High Energy Phys. **5**, 11 (1998)
    Barcelona-Marseille

12. M. Knecht, S. Peris and E. de Rafael, *The Electroweak $\pi^+ - \pi^0$ mass difference and weak matrix elements in $1/N_c$ expansion*, Phys. Lett. **B443**, 255 (1998)
    Barcelona-Marseille

13. J. Bijnens, E. Pallante and J. Prades, *Obtaining $K \to \pi\pi$ from off-shell $K \to \pi$ amplitudes*, Nucl. Phys. **B521**, 305 (1998)
Bern-Granada-Lund

14. E. Oset, J.A. Oller, J.R. Pelaez and A. Ramos, *Meson-meson and meson-baryon interactions in a chiral nonperturbative approach*, Acta Phys. Polon. **B29**, 3101 (1998)
Barcelona-Valencia

15. H. Neufeld, J. Gasser and G. Ecker, *The one-loop functional as a Berezinian*, Phys. Lett. **B438**, 106 (1998)
Bern-Wien

16. J. Bijnens, G. Colangelo and G. Ecker, *Double chiral logs*, Phys. Lett. **B441**, 437 (1998)
Bern-Lund-INFN-Wien

17. J. Bijnens, G. Colangelo and G. Ecker, *The mesonic chiral Lagrangian of $O(p^6)$*, J. High Energy Phys. **2**, 20 (1999)
Lund-Wien-Zurich

18. J. Bijnens, P. Gosdzinsky and P. Talavera, *Chiral Corrections to Vector Meson Decay Constants*, Phys. Lett. **B429**, 111 (1998)
Barcelona-Lund

19. J. Bijnens, G. Colangelo and P. Talavera, *The Vector and Scalar Form Factors of the Pion to Two Loops*, J. High Energy Phys. **5**, 14 (1998)
Barcelona-INFN-Lund

20. J. Bijnens and J. Prades, *The $\Delta I = 1/2$ Rule in the Chiral Limit*, J. High Energy Phys. **1**, 23 (1999)
Granada-Lund

21. J. Gasser and M.E. Sainio, *Two-loop integrals in chiral perturbation theory*, Eur. Phys. J. **C6**, 297 (1999)
Bern-Helsinki

22. G. D'Ambrosio, G. Ecker, G. Isidori and H. Neufeld, *$\eta \to \pi^+\pi^-\pi^0\gamma$ in chiral perturbation theory*, Phys. Lett. **B466**, 337 (1999)
INFN-Wien

23. N.H. Fuchs, M. Knecht and J. Stern, *Contributions of order $O(m_{quark}^2)$ to K_{l3} form factors and unitarity of the CKM matrix*, Phys. Rev. **D62**, 033003 (2000)
Marseille-Paris

24. M. Knecht, S. Peris, M. Perrottet and E. de Rafael, *Decay of Pseudoscalars into Lepton Pairs and Large–N_c QCD*, Phys. Rev. Lett. **83**, 5230 (1999)
Barcelona-Marseille

25. L. Ametller, J. Kambor, M. Knecht and P. Talavera, *Low-energy photon-photon fusion into three pions in generalized chiral perturbation theory*, Phys. Rev. **D60**, 094003 (1999)
Barcelona-Lund-Marseille-Zurich

26. M. Knecht, H. Neufeld, H. Rupertsberger and P. Talavera, *Chiral perturbation theory with virtual photons and leptons*, Eur. Phys. J. **C12**, 469 (2000)
Marseille-Lund-Vienna

27. J. Bijnens and J. Prades, *Scheme Dependence of Weak Matrix Elements in the $1/N_c$ Expansion*, J. High Energy Phys. **1**, 2 (2000)
Granada-Lund

28. J. Bijnens, G. Colangelo and G. Ecker, *Renormalization of chiral perturbation theory to order p^6*, Ann. Phys. **280**, 100 (2000)
Lund-Wien-Zurich

Masses and Form Factors

29. A. Pich and J. Prades, *Perturbative quark mass corrections to the tau hadronic width*, J. High Energy Phys. **6**, 13 (1998)
Granada-Valencia

30. A. Grau, G. Pancheri and Y.N. Srivastava, *Hadronic total cross-sections through soft gluon summation in impact parameter space*, Phys. Rev. **D60** , 114020 (1999)
Granada-INFN

31. J. Charles, A. Le Yaouanc, L. Oliver, O. Péne and J.-C. Raynal, *Heavy to light form-factors in the heavy mass to large energy limit of QCD*, Phys. Rev. **D60**, 014001 (1999)
Barcelona-Paris

32. J. Charles, A. Le Yaouanc, L. Oliver, O. Péne and J.-C. Raynal, *Heavy to light form-factors in the final hadron large enegy limit: covariant quark model approach*, Phys. Lett. **B451** (1999) 187.
Barcelona-Paris

33. A. Pich and J. Prades, *Strange Quark Mass Determination from Cabibbo-Suppressed Tau Decays*, J. High Energy Phys. **10**, 4 (1999)
Granada-Valencia

34. O. Panella, C. Carimalo and Y.N. Srivastava, *Production of like sign dileptons in p-p collisions through composite Majorana neutrinos*, Phys. Rev. **D62**, 015013 (2000)
INFN-Paris

Meson Spectroscopy

35. K. Melnikov, F. Nguyen, B. Valeriani and G. Venanzoni, *Contribution of the direct decay $\phi \to \pi^+\pi^-\gamma$ to the process $e^+e^- \to \pi^+\pi^-\gamma$ at Daϕne*, Phys. Lett. **B 477**, 114 (2000)
INFN-Karlsruhe

36. A. Bramon, R. Escribano, J.L. Lucio M. and G. Pancheri, *The ratio $\Phi \to K^+K^-/K^0\bar{K}^0$*, Phys. Lett. **B486**, 406 (2000)
Barcelona-INFN

Strange Baryons

37. T.S. Lee, J.A. Oller, E. Oset and A. Ramos, *Nonperturbative chiral approach to* $K^- p \to \gamma Y$ *reactions*, Nucl. Phys. **A643**, 402 (1998)
Barcelona-Valencia

38. E. Oset and A. Ramos, *Weak decay of Lambda hypernuclei*, Progr. Part. Nucl. Phys. **41**, 191 (1998)
Barcelona-Valencia

39. A. Ramos, A. Parreno, C. Bennhold, E. Oset, L.L. Salcedo and M.J. Vicente-Vacas, *Non-mesonic weak decay of Lambda hypernuclei*, Nucl. Phys. **A639**, 307 (1998)
Barcelona-Valencia

40. E. Oset and A. Ramos, *Non perturbative chiral approach to s-wave anti-K N interactions*, Nucl. Phys. **A635**, 99 (1998)
Barcelona-Valencia

41. J. C. Nacher, E. Oset, H. Toki and A. Ramos, *Radiative production of the Lambda(1405) resonance in K collisions on protons and nuclei*, Phys.Lett. **B461**, 299 (1999)
Barcelona-Valencia

42. W. M. Alberico and G. Garbarino, *The* Δ *I=1/2 rule in non-mesonic weak decay of Lambda hypernuclei*, Phys. Lett. **B486**, 362 (2000)
INFN-Oxford

43. J.A. Oller, E. Oset and A. Ramos, *Chiral Unitary approach to meson-meson and meson-baryon interactions and nuclear applications*, Prog. Part. Nucl. Phys. **45**, 157 (2000)
Barcelona-Valencia

44. A. Ramos and E. Oset, *The properties of* $\bar{K}$ *in the nuclear medium*, Nucl. Phys. **A671**, 481 (2000)
Barcelona-Valencia

45. S. Hirenzaki, Y. Okumura, H. Toki, E. Oset and A. Ramos, *Chiral unitary model for kaonic atoms*, Phys. Rev. **C61**, 055025 (2000)
Barcelona-Valencia

46. J. C. Nacher, A. Parreño, E. Oset, A. Ramos, A. Hosaka and M. Oka, *Chiral Unitary Approach to the N*N*pi, N*N*eta Couplings for the N*(1535) Resonance*, Nucl. Phys. **A678**, 187 (2000)
Barcelona-Valencia

47. W. M. Alberico, A. De Pace, G. Garbarino and A. Ramos, *Weak decays of medium and heavy Lambda hypernuclei*, Phys. ReV. **C61**, 044314 (2000)
Barcelona-INFN

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1. A. Ramos and E. Oset, *Antikaons in the medium within a chiral non-perturbative approach*, XV Particles and Nuclei International Conference, Uppsala (Sweden), June 1999, Nucl. Phys. A 663,664 (2000) 525c-528c,
Barcelona-Valencia

2. E. Oset, A. Hosaka, J.C. Nacher, M. Oka, J.A. Oller, A. Parreño, J.R. Peláez, A. Ramos and H. Toki, *SU(3) Chiral approach to meson and baryon dynamics*, XV Particles and Nuclei International Conference, Uppsala (Sweden), June 1999, Nucl. Phys. A 663,664 (2000) 497c-500c,
Barcelona-Valencia

3. S. Hirenzaki, T. Hatsuda, K. Kume, T. Kunihiro, H. Nagahiro, Y. Okumura, E. Oset, A. Ramos, H. Toki and Y. Umemoto, *Physics of mesonic atoms and mesonic nuclei: structure and formation*, XV Particles and Nuclei International Conference, Uppsala (Sweden), June 1999, Nucl. Phys. A 663,664 (2000) 553c-556c,
Barcelona-Valencia

4. A. Pich and J. Prades, *Strange quark mass dependence of the tau hadronic width*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'98– (Montpellier, France, July 1998), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) 74 (1999) 309–312,
Granada-Valencia

5. M. Knecht, S. Peris and E. de Rafael, *A new approach to weak amplitudes in large N_c QCD*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'99– (Montpellier, France, July 1999), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) 86 (2000) 279–293,
Barcelona-Marseille

6. A. Ramos and E. Oset, *Chiral approach to antikaon dynamics in the nuclear medium*, XI International Workshop on New Directions in QCD, Kyunjy (Korea), June 1999, AIP Conference Proceedings
Barcelona-Valencia

7. A. Ramos and E. Oset, *Antikaons in the medium with a chiral nonperturbative approach*, PANIC99 Conference, Uppsala, June 1999,
Barcelona-Valencia

8. A. Pich and J. Prades, *Tau decay determination of the strange quark mass*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'99– (Montpellier, France, July 1999), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) 86 (2000) 236–241,
Granada-Valencia

9. J. Gasser and M. E. Sainio, *Sigma term physics*, 3RD WORKSHOP ON PHYSICS AND DETECTORS FOR DAPHNE (DAPHNE 99), Frascati, Italy, 16-19 Nov 1999, hep-ph/0002283, to appear in the Proceedings
Bern-Helsinki

10. E. Oset, E. Marco, J.C. Nacher, J.A. Oller, J.R. Peláez and A. Ramos, *Photoproduction of meson and baryon resonances in a chiral unitary approach*, Erice Summer School of Nuclear Physics, 21th course: Electromagnetic Probes and the Structure of Hadrons and Nuclei, September 1999, Prog. Part. Nucl. Phys. **44** (2000) 213,
Barcelona-Valencia

11. E. Oset, J.A. Oller, J.R. Peláez, A. Ramos, H. C. Chiang, F. Guerrero, S. Hirenzaki, T. S. H. Lee, E. Marco, J. C. Nacher, Y. Okumura, A. Parreño, H. Toki and M. J. Vicente-Vacas, *Recent progress on the chiral unitary approach to meson meson and meson baryon interactions*, International Symposium on Physics of Hadrons and Nuclei, Tokyo (Japan), December 1998, Nucl. Phys. **A670** (2000) 111,
Barcelona-Valencia

12. E. Oset, E. Marco, J. C. Nacher, A. Ramos and H. Toki, *Chiral symmetry in electromagnetically induced two hadron production*, IV Workshop on electromagnetically induced two hadron emission, (Granada, May 1999), nucl-th/9907102,
Barcelona-Valencia

13. E. Oset, S. Hirenzaki, Y. Okumura, A. Ramos, H. Toki and M. J. Vicente-Vacas, *Chiral Unitary Approach to the $\bar{K}$ nucleus interaction and kaonic atoms*, Meson 2000 Conference (Krakow, Poland, May 2000), nucl-th/0006002,
Barcelona-Valencia

Published in the Bulletin Board

1. J. Charles, F. De Fazio *et al.*, *B-decays at LHC*, hep-ph/0003238
Barcelona-Durham

2. S. Peris and E. de Rafael, K^0-$\bar{K}^0$ *Mixing in the* $1/N_c$ *Expansion*, hep-ph/0006146
Barcelona-Marseille

3. S. Peris, B. Phily and E. de Rafael, *Tests of Large-N_c QCD from Hadronic τ Decay*, hep-ph/0007338
Barcelona-Marseille

4. A. Bramon, R. Escribano, J.L. Lucio M., M. Napsuciale and G. Pancheri *Chiral loops and $a_0(980)$ exchange in $\phi \to \pi^0\eta\gamma$*, hep-ph/0008188. To be published in Phys. Lett. B.
Barcelona-INFN

5. E. Oset and A. Ramos, *ϕ decay in nuclei*, nucl-th/0005046
Barcelona-Valencia

6. G. Ecker, G. Isidori, G. Müller, H. Neufeld and A. Pich, *Electromagnetism in nonleptonic weak interactions*, hep-ph/0006172
INFN-Valencia-Wien

7. E. Pallante and A. Pich, *Final state interactions in kaon decays*, hep-ph/0007208
Barcelona-Valencia

B - Comparison with the Project Program

B1. Research Objectives

The main objective of this network was to investigate problems on fundamental symmetries, electroweak and strong QCD physics that could be explored at the European ϕ-factory DAPHNE, which was completed in November 1998. This fundamental objective has not changed. In addition, as complementary results from other accelerators on the same physics issues have appeared, the research objectives of our network have included the understanding of these results as well.

The theoretical work undertaken by this group has been in line with what had been anticipated in the project plan, with some **new** entries, indicated in the following in bold face.

THEORY ISSUES

(i) CP and CPT Physics in the Kaon and **the B-meson** system;

(ii) Chiral Perturbation Theory and Models for low-energy dynamics of light and strange quarks;

(iii) K and η Decays;

(iv) a novel analysis of pion-pion scattering at threshold and phase shift structure from K decay;

(v) Total hadronic cross-section in electron-positron collisions below 2 GeV and **the radiative return** method;

(vi) Vector Mesons in effective lagrangians;

(vii) Gluon dynamics and spectroscopy **at, below** and above the phi-meson;

(viii) Nuclear Physics with Kaons from ϕ-decays.

Through these studies the network aims to attain the following research objectives : Objectives

1. To help clarify the origin of CP violation.
2. To sharpen existing predictions of Chiral Perturbation Theory.
3. To improve the understanding of rare kaon decays and possibly to disentangle short distance effects.
4. To investigate the implications of precision data on $e^+e^- \to hadrons$ at low energy from both the experimental and the theoretical point of view.
5. To understand the nature of the enigmatic scalar mesons which appear just below 1 GeV and which will be produced in radiative ϕ-decays.

These objectives are still relevant as one can see from the fact that there are now new experimental proposal to study both CP violation and K-decays, that new data have appeared in this field, with still contradictory results (the central values of recent ϵ'/ϵ measurements are still more than two standard deviations apart), that the work done by the theorists of this network is the standard reference work on K-decays. Similar observations hold for all of the other research objectives. These objectives also appear achievable during the lifetime of our project, as we show in in Sect. **B 3** where the goals and milestones relevant to our project are analyzed in detail.

B.2 Methodological Approach and Work Plan

There have been no changes in the methodological approach employed by the theorists in the EURODAPHNE project and the work plan has also remained very close to the original one described in the contract.

The joint program of work had been originally been broken down into major tasks. The table in the contract, which indicated to which task nodes planned to work, is now reproduced as Table 1. To update the original table, we have introduced the following notation : while the marking $\times$ corresponds to the original committment, a new marking, $\otimes$, indicates a commitment which has already resulted in published work or work in progress, whereas $\bullet$ indicates a new commitment with work done or in progress. As one can see, most of the teams are in fact already fulfilling their assigned task. At the same time, as the scientific interest or need naturally moves according to new advances in the field, one can see new aggregations, not necessarily provided for in the original contract.

EURODAPHNE Scientific Plan and Tasks Assignments

Country	**IT**	**GB**	**FR**		**ES**		**AT**	**DE**	**FI**	**CH**
Participant Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
CP and CPT physics in the Kaon system	$\otimes$			$\otimes$	$\bullet$	$\otimes$	$\otimes$		$\otimes$	
Theoretical issues in ChPT										
Standard ChPT	$\otimes$		$\times$	$\otimes$	$\otimes$	$\otimes$	$\otimes$		$\otimes$	$\otimes$
Quenched ChPT	$\times$			$\otimes$					$\otimes$	$\otimes$
Chiral Symmetry Breaking			$\otimes$	$\otimes$		$\times$	$\otimes$		$\otimes$	$\otimes$
K-meson, η and η' decays					$\bullet$					
$K_{\mu 3}$	$\times$			$\otimes$			$\bullet$			$\times$
K_{l4}	$\times$	$\otimes$	$\times$	$\times$			$\bullet$		$\otimes$	$\otimes$
All other decays	$\otimes$		$\times$	$\times$	$\otimes$	$\otimes$	$\otimes$		$\otimes$	$\otimes$
QED Radiative corrections	$\times$		$\times$				$\bullet$	$\otimes$	$\bullet$	
$\pi\pi$ scattering at threshold and phase shifts	$\times$		$\otimes$	$\times$	$\times$	$\times$	$\otimes$		$\otimes$	$\otimes$
Structure and role of Vector mesons										
Vector Mesons in Eff. Lagrangians	$\otimes$				$\times$	$\otimes$			$\otimes$	
Vector Meson spectroscopy		$\otimes$			$\otimes$					
e^+e^- cross-sections below 2 GeV										
$e^+e^- \rightarrow$ *hadrons* **and** $(g-2)_\mu$				$\times$	$\times$	$\otimes$		$\otimes$	$\bullet$	
$\gamma\gamma \rightarrow$ *hadrons*	$\otimes$	$\otimes$	$\otimes$		$\bullet$	$\bullet$				$\otimes$
QED Radiative corrections	$\otimes$		$\times$					$\otimes$		
QED Processes for calibration	$\otimes$		$\times$							
Hadron spectroscopy at the Φ		$\otimes$	$\times$			$\otimes$			$\otimes$	
Gluon dynamics and spectrosopy above the Φ		$\otimes$	$\times$						$\times$	
Nuclear physics with Kaons	$\otimes$	$\otimes$			$\otimes$	$\otimes$				

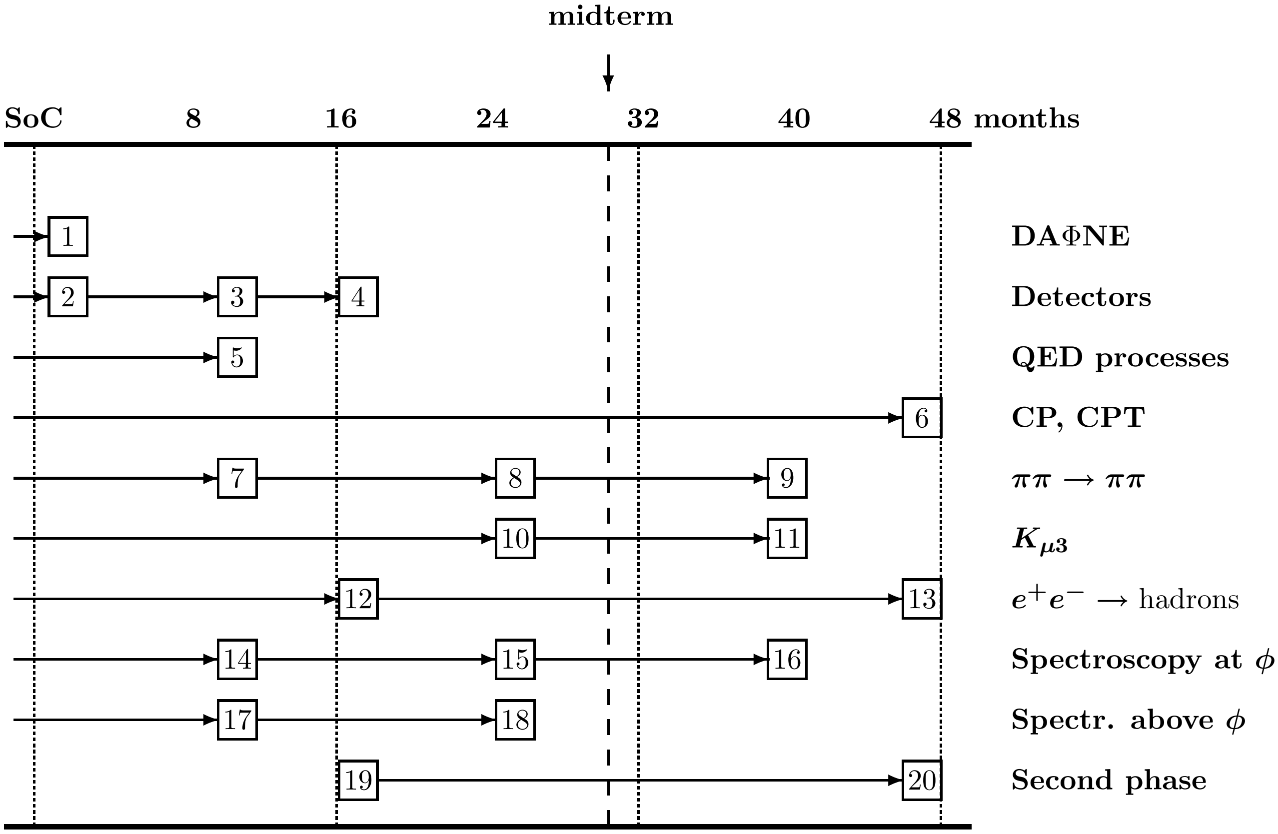
Table 1: *List of specific tasks on which the teams, indicated by participant number, are working during this research project.* $\times$ *corresponds to a commitment in the contract,* $\otimes$ *corresponds to work specified in the commitment that is already finished or is in progress and* $\bullet$ *signifies finished work or work in progress that was not already specified in the contract.*

B.3 Schedules and Milestones

The EURODAPHNE project is a joint effort between experimentalists and theorists, aimed to extract informations in the low energy regime explored by the accelerator DAΦNE . As such, some of our milestones are necessarily connected to the progress of the machine and/or the experimental program and may not be completely in line with the original milestones. Such is the case for two particular items, the last ones in the milestone table, which both included the preparation of a theoretical report for the Second Phase of the DAΦNE machine and have not been tackled yet. This second phase is still quite away in the future and work on this item has not yet started. We plan to discuss this particular aspect of our project in a forthcoming Executive Committee Meeting, in order to decide whether the outlook for the upgrade of DAΦNE is indeed positive.

Concerning the other milestones, the general schedule of our work appears well in line with the predictions. To illustrate this, we reproduce the milestone table in our contract with different markings to indicate whether a given milestone has been reached or not. Complementary to the table, a series of comments following the table are meant to support our assessment, via a bibliographic information.

B.3 EURODAPHNE Schedule and Milestones



Legend

SoC=Start of Contract / $\surd$ completed / ($\surd$) near completion / ($\bullet$) work in progress

1 DAΦNE commissioned $\surd$
2 DEAR in operation $\surd$
3 KLOE and FINUDA in operation: KLOE $\surd$ FINUDA ($\bullet$)
4 Data analysis starts $\surd$
5 QED calibration processes at work $\surd$
6 ϵ'/ϵ determined ($\bullet$)
7 Theoretical predictions for amplitude at order p^6 completed $\surd$
8 Theoretical work for extraction of $\pi\pi$ phases from K_{le4} decays completed ($\surd$)
9 Size of quark condensate determined ($\bullet$)
10 Theoretical work for $K_{\mu 3}$ decay analysis completed ($\bullet$)
11 Scalar radius in $K_{\mu 3}$ determined ($\bullet$)
12 Interplay between measurements at DAΦNE and τ-decays investigated $\surd$
13 Radiative corrections to hadronic cross section completed ($\surd$)
14 Theoretical work on a_0/f_0 mixing effects completed ($\bullet$)
15 Full dynamical predictions for $\phi \to a_0/f_0\gamma$ completed $\surd$
16 Theoretical assessment on scalar ($\surd$) and vector mesons ($\bullet$)
17 Theoretical work on excited Vector Mesons assessed ($\surd$)
18 Signals for C=+ states for DAΦNE second phase computed ($\bullet$)
19 Beginning of theoretical work on DAΦNE Second Phase
20 Completion of report on physics at DAΦNE Second Phase

Comments on particular issues

7 Theoretical predictions for amplitude at order p^6

Relevant references include

M. Knecht, B. Moussallam, J. Stern and N. H. Fuchs, Nucl. Phys. **B457** (1995) 513 [hep-ph/9507319].
J. Bijnens, G. Colangelo, G. Ecker, J. Gasser and M. E. Sainio, Nucl. Phys. **B508** (1997) 263 [hep-ph/9707291].
J. Bijnens, G. Colangelo and G. Ecker, JHEP **9902** (1999) 020 [hep-ph/9902437].
J. Bijnens, G. Colangelo and G. Ecker, Annals Phys. **280** (2000) 100 [hep-ph/9907333].

The final predictions at order p^6 are given in

G. Colangelo, J. Gasser and H. Leutwyler, Phys. Lett. **B488** (2000) 261 [hep-ph/0007112].

8 Theoretical work for extraction of $\pi\pi$ phases from K_{l4} decays

The analysis of K_{l4} data is discussed in

G. Amoros and J. Bijnens, J. Phys. G **G25**, 1607 (1999) [hep-ph/9902463].
B. Ananthanarayan, G. Colangelo, J. Gasser and H. Leutwyler, hep-ph/0005297.

Predictions are given in

G. Amoros, J. Bijnens and P. Talavera, Phys. Lett. **B480**, 71 (2000) [hep-ph/9912398].
G. Amoros, J. Bijnens and P. Talavera, hep-ph/0003258, to be published in Nucl. Phys. B

Radiative corrections

The calculation of radiative corrections to the K_{l3} decays is in progress [1]. Radiative corrections to the hadronic form factors themselves are already discussed in earlier papers [2,3]. The calculation of the contributions involving virtual photon exchanges between mesons and leptons are now being completed within the framework defined in [4]. Work aiming at a theoretical determination of the low-energy constants involved in radiative corrections to semi-leptonic decays of light mesons is also underway [5]. Future plans include the study of radiative corrections to the K_{l4} modes, as well as to the pion and kaon beta decays.
[1] M. Knecht, H. Neufeld, H. Rupertsberger and P. Talavera, work in progress.
[2] H. Neufeld and H. Rupertsberger, Z. Phys. **C 68**, 91 (1995).
[3] H. Neufeld and H. Rupertsberger, Z. Phys. **C 71**, 131 (1996).
[4] M. Knecht, H. Neufeld, H. Rupertsberger and P. Talavera, Eur. Phys. J. **C 12**, 469 (2000).
[5] M. Knecht and A. Nyffeler, work in progress.

9 Quark condensate

Work on the condesates is published in

S. Descotes, L. Girlanda and J. Stern, JHEP **0001** (2000) 041 [hep-ph/9910537].
S. Descotes and J. Stern, Phys. Rev. **D62** (2000) 054011 [hep-ph/9912234].
S. Descotes and J. Stern, Phys. Lett. **B488** (2000) 274 [hep-ph/0007082].

10 Theoretical work for K_{l3} decay analysis

Chiral predictions

The one-loop prediction exists since more than 15 years, including an estimate of higher order corrections. Work on a genuine two-loop calculation is in progress at the *Lund* node. See also
N. H. Fuchs, M. Knecht and J. Stern, Phys. Rev. **D62** (2000) 033003 [hep-ph/0001188].

Radiative corrections

Radiative corrections need be perforemd as well. The foundations are published, the calculation itself is in progress, see same issue in point 7 discussed above.

12 Interplay between measurements at DAΦNE and τ-decays

Theoretical Analysis

On the basis of isospin relations it was demonstrated that the amplitude for one suitably chosen four pion final state, e.g. $\pi^+\pi^-2\pi^0$, determines the amplitude for $2\pi^+2\pi^-$ and, in addition, for the final states $\pi^-3\pi^0$ and $2\pi^-\pi^+\pi^0$ accessible in τ lepton decays

Relevant references include

J.H. Kühn, The Tau Lepton: Particle Physics in a Nutshell Nucl. Phys. **B** (Proc. Suppl.) **76** (1999) 21-44.

13 Radiative corrections to hadronic cross section

Present status

The present status of radiative correction estimates goes substantially beyond previous calculations. Leading order corrections are completed, a next-to-leading order calculation is in progress.

Relevant Publications

[1] V.A. Khoze, M.I. Konchatnij, N.P. Merenkov, G. Pancheri, L. Trentadue, O.N. Shekhovzova, *Radiative corrections to the hadronic cross-section measurement at Daphne.* Preprint LNF-00-015-P, hep-ph/0003313.
[2]A. Hoefer, J. Gluza, F. Jegerlehner, *Pion Pair Production with Higher Orders Radiative Corrections in Low Energy* e^+e^- *Collisions*, to be published

14 Theoretical work on a_0/f_0 mixing effects

Isospin breaking, mixing and the glueball

In addition to the original seminal work done by the UK node since more than 5 years ago, assessment of the mixing situation and comparison with new theretical and experimental entries have shed new light on the mixing problem.

Relevant references include

[1] F. Close and A. Kirk, Phys. Lett. **B489** (2000) 24.
[2] F. Close and A. Kirk, Phys. Lett. **B477** (2000) 13.
[3] F. Close and A. Kirk, Phys. Lett. **B483** (2000) 345.

15 Full dynamical predictions for $\phi \to a_0/f_0\gamma$

Theory versus Experiment

Work is in progress to compare the theoretical predictions with the experimental data being analyzed presently at Frascati.

Relevant publications include

[1] M.E. Boglione and M.R. Pennington, *Determination of Radiative Widths of Scalar Mesons from Experimental Results on* $\gamma\gamma \to \pi\pi$, Eur. Jour. of Phys. (in press)
[2] A. Bramon, R. Escribano, J.L. Lucio M. and G. Pancheri, Phys. Lett. **B486** (2000) 406.
[3] A. Bramon, R. Escribano, J.L. Lucio M., M. Napsuciale and G. Pancheri, hep-ph/0008188. To appear in Physics Letters B.

16 Theoretical assessment on scalar and vector mesons

The σ *meson is back into the PDG*

Due to the efforts of the Helsinki node, the light sigma meson near 500-600 MeV is accepted as a true resonance and is quoted as such in the latest edition of the Particle Data Book.

Relevant Publications

[1] D.E. Groom,.. N.A. Törnqvist, et al., Eur. Phys. J. **C15** (2000).
[2] N.A. Törnqvist, Eur. Phys. J. **C 11** (1999) 359.

The ρ *meson*

The ρ meson line shape is being determined and compared with KLOE measurements.

Relevant Publications

E. Marco, S. Hirenzaki, E. Oset and H. Toki, Phys. Let. **B470** (1999) 20.

17 Theoretical work on excited Vector Mesons

Current state

The evidence for the presence of hybrid vectors is now quite strong and the consequences for further vector searches in the low energy region examined.

Relevant Publications include

A. Donnachie and Y. Kalashnikova, Phys. Rev. **D60** (1999) 114011.

18 Signals for C=+ states for DAΦNE second phase

[1] F E Close and G Schuler, Phys. Lett B458, 127 (1999).
[2] F E Close and G Schuler, Phys. Lett. **B464** (1999) 279.
[3] F E Close, A. Kirk and A. Schuler, Phys. Lett. **B 477** (2000) 13.

B.4 Research Effort of the Participants

In Table 2 we compare, in tabular form, the professional effort that each team has so far contributed to the joint programme of work against that foreseen in the contract. No significant variations can be observed, apart from a slight reduction in the number of senior researchers working on the project in the INFN node. This can be attributed to the fact that the experimental analysis is slowed down, due to the delays in bringing DAΦNE to the design luminosity and hence a reduced interest by the part of a number of theorists, until the data will arrive. In addition, some of the theorists originally participating to this project have since joined other networks and their participation has been reduced. One of our participants to the INFN node, L. Maiani, has also moved to CERN. Notice, however, that the overall network man/woman-power has kept its original strength, thanks to new participations from other nodes.

$N.^o$	Team	Contr. (a)	Actual (a)	Contr. (b)	Actual (b)	Contr. (c)	Actual (c)
1	INFN-LNF	54	29	558	255	25	17
2	UKRAL	66	30	258	97	14	8
3	CNRS-IN2P3	24	4	256	116	10	9
4	CNRS-CPT	24	0	156	80	7	5
5	UAB	24	11	504	353	13	17
6	UVEG	24	10	164	239	9	10
7	UWIEN	24	13	120	86	5	6
8	DESY-ZEU	36	20	380	237	12	15
9	UHELS	36	31	120	102	5	6
10	UBERN	24	14	260	253	12	14
Total		336	162	2776	1813	112	113

Table 2: (a) = person-months of young researchers to be financed by the contract and financed as of August 31^{st} 2000; (b) = person-months of researchers contributing to the effort compared with total (it includes (a)). It should be noted that the second column under (b) was obtained from the numbers after 24 months (as stated in the first two annual reports) by multiplying with 29/24 to determine the person-months for a period of 29 months. (c) = number of individual researchers likely to contribute to the network project and average number so far.

B.5 Cohesion with Less Favoured Regions

In our network, there are two subnodes and one node located in less favoured regions, namely Granada in Andalusia, Thessaloniki in Greece and DESY-Zeuthen in Brandenburg. Both Granada and DESY-Zeuthen are extremely well integrated in the network.

GRANADA

For Granada, integration in the network is demonstrated by the success of the Collaboration Meeting held in Granada, in February 2000, and organized by the Granada subnode. There are also many close links between Granada and the other nodes and subnodes, some of which presently include :

- A long standing collaboration between G. Pancheri from Frascati and A. Grau from Granada, presently focussed on understanding the low energy behavior of hadronic form factors.
- A collaboration between J. Prades from Granada and J. Bijnens from Lund which has made several major steps forward in understanding the value of both ϵ' and ϵ in the standard model.
- A collaboration between F. Cornet from Granada and J. Gasser Bern, concerning kaon-nucleon scattering, is presently being set up.

DESY-ZEUTHEN

As for DESY Zeuthen, this node, together with its Karlsruhe subnode, is in charge of one of the major research objectives, the study of the muon anomaly. Researchers from these nodes frequently exchange visits with Frascati Laboratories, participate actively to all of our meetings and to the Spring School. DESY-Zeuthen and Karlsruhe have organized in Frascati one of the topical meetings, last May, during the Spring School. Scientists from Karlsruhe are part of the experimental group KLOE working on extracting data from DAΦNE .

This network also includes a subnode of the UK group, based at the University of Thessaloniki. This group, which has collaborated with EURODAPHNE in the past, has not been very active yet, partly because the expected extension of the DAΦNE program to higher energies and thus exploration of vector meson resonances, has not been implemented. Nonetheless, it is hoped to have a more active participation in the remaining period, and to this end we plan to invite George Gounaris from University of Thessaloniki, to Frascati for some length of time. THESSALONIKI

B.6 Network Organization and Management

The means, by which the network is coordinated and the research work is organized, fall into different categories. The network planning is based on joint work between the Coordinator and the Executive Committee, which meets at least twice a year and is often consulted by the Coordinator. The Executive Committee Meetings are usually not longer than one day, and are often organized during other network meetings. The following Executive Committee Meetings have formally taken place since the beginning of the contract : NETWORK PLANNING EXECUTIVE COMMITTEE MEETINGS

1. October 20th, 1998 in Paris, during the 2^{nd} Collaboration Meeting
2. February 20th, 1999 in Frascati to approve hiring decisions
3. April 14th, 1999 in Frascati, during 3^{rd} Collaboration Meeting
4. November 18th, 1999 during the *1999 Workshop on Physics and Detectors for DAΦNE*
5. February 12th, 2000 in Granada, during the 4^{th} Collaboration Meeting

For more detailed network management, rounds of telephone calls between the Coordinator and the scientists in charge, as well as personal visits, have also proven very valuable. Many issues concerning hiring of young researchers have been settled by direct exchange, visits by the Coordinator to some nodes have helped finding a solution to conflicts between nodes, planning of meetings or again hiring problems. COORDINATOR VISITS

All other activities fall into three major categories, namely electronic communications, person-to-person exchanges, and network meetings. Electronic communications consists both of e-mail exchanges, mostly concerning preparation of common reports, or meetings, and use of the network web-page, with address WEB PAGE

http://www.lnf.infn.it/theory/tmr/ where all the network publications are listed, with links to the major e-print database where copies of papers can be obtained from. The web page also contains a link to the full 800 pages of the Second DAΦNE Physics Handbook, a continuing reference work for our group. In the web page, meetings of interest to the Collaboration are announced, vacancies are posted. The web page is particularly useful for coordinating information about past and present meetings, topical or general.

General or topical Meetings remain the main tool for research progress, of course. Since the beginning of the contract, the following general or topical meetings have taken place : NETWORK MEETINGS

1. 1^{st} Collaboration Meeting within the Contract.
(6^{th} EuroDaΦne Collaboration Meeting)

Date: 14 - 18 April 1998.
Place: Frascati.
Organized by: G. Pancheri.

This collaboration meeting was held together with 1998 LNF Spring School. There were 81 participants, including young researchers and lecturers from outside the network. The scope was both to gather the collaboration together after the signature of the Contract and to introduce new network members to the already existing group. Physics highlights included lectures on CP-violation, nucleon structure and light meson spectroscopy.

2. Workshop on K_{l4}-decays

Date: 29 - 30 June 1998.
Place: Bern.
Organized by: J. Gasser.

There were about 40 participants, mostly from the network, but also from outside, like from Brookhaven and Yale. The aim of this workshop was to study how to extract the information on the pion-pion scattering length from the upcoming K-decay measurements at DAΦNE and at Brookhaven.

3. Radiative Corrections Meeting

Date: October 6, 1998.
Place: Frascati.
Organized by: G. Pancheri.

The aim was to study radiative corrections to luminosity and the measurement of the hadronic cross-section at DAΦNE. It involved about 30 participants, from the network and the experimental group working at DAΦNE.

4. 2^{nd} Collaboration Meeting

Date: 19 - 21 October 1998.
Place: Paris.
Organized by: J. Stern.

The meeting discussed the status of the network as a whole and plans for future and immediate work were drawn. The meeting was attended by 51 participants, including external speakers.

5. 3^{rd} Collaboration Meeting

Date: 15 - 17 April 1999.
Place: Frascati.
Organized by: G. Pancheri.

Since the Collaboration Meeting was held together with the Frascati Spring School, about 50% of the 110 participants were not part of the network. They included also the School lecturers, who gave lectures om Higgs searches, Neutrino masses, CP-violation.

6. Meeting on Scalar Mesons

Date: 18 - 19 September 1999.
Place: Durham.
Organized by: M. Pennington.

The scope of this meeting was to discuss the issue of Φ-decays into scalar mesons and the information to be obtained about the structure of such decays. Participation was restricted to network members and included 19 participants.

7. Meeting on Hadronic Atoms

Date: 14 - 15 October 1999.
Place: Bern.
Organized by: J. Gasser and A. Rusetsky.

Scope of the meeting was to assess the state-of-the-art concerning pionic atoms, discussion of new solutions to Roy equations studied by the Zuerich and Bern group, and outlook for the experiment on Kaonic atoms at Frascati. About 50 physicists were participating, including participants from outside the network, CERN, Juelich, Prague and Heidelberg.

8. 4^{th} Collaboration Meeting

Date: 10 - 12 February 2000.
Place: Granada.
Organized by: A. Grau and F. Cornet

There were 54 participants, all of them from the network. All young people presented their work, and there was also extensive discussion of the program of the yearly Frascati Spring School which is attended by all the young researchers of the network.

9. Meeting on Measurement of Sigma Hadronic

Date: May 20, 2000.
Place: Frascati.
Organized by: W. Kluge and G. Venanzoni.

The meeting took place at the end of the Frascati Spring School, with about 30 participants from the network, and some scientists from outside the European Union. The meeting, organized by the Karlsruhe group, assessed the progress done both theoretically and experimentally, concerning the precision measurement of the electron-positron cross-section into hadrons.

B.7 Connection to Industry

As stated in our project plan, this project is based on theoretical physics and phenomenological studies and as such is not directly related to technological spin-off on industry.

C. Training

C.1 Employment of young reseachers

In Table 3 we summarize the number of young researchers (in man-months) whose employment has so far been financed by the contract and compare it with the overall deliverable specified in the contract.
Complementary to this table, we show in Table 4 our training plan, including past, present and expected hiring to the end of the contract. We notice that all the positions available in

Participant	Young Researchers financed by contract so far (person-months)			Contract Deliverable of young researchers to be financed by the contract (person-months)		
	Pre-doc	Post-doc	Total	Pre-doc	Post-doc	Total
1. LNF	6	23	29	18	36	54
2. UKRAL	15	15	30	30	36	66
3. CNRS-IN2P3		4	4	12	12	24
4. CNRS-CPT		0	0		24	24
5. UAB		11	11		24	24
6. UVEG		10	10		24	24
7. UWIEN		13	13		24	24
8. DESY-ZEU		20	20		36	36
9. UHELS		31	31		36	36
10. UBERN		14	14		24	24
Total	21	141	162	60	276	336

Table 3:

$N.^o$	Team	Months		Presently or already Hired	Planned to start after September 2000	Still unassigned
–	–	PD	S			
1	INFN-LNF	36	18	G. Hiller 12 (Post-doc) R. Escribano 24(Post-doc) H. Pichl 12(PhD. Stud.)	H. Pichl 6 (post-Doc)	
2	UKRAL	36	30	K. Benhaddou 15 (M.Sc. stu.) F. De Fazio 22 (Post-doc) G. Garbarino 6(Post-doc)	M.E. Boglione 12 (Post-doc) K. Benhaddou 11 (PhD Stud.)	
3	CNRS-IN2P3	12	12	P. Talavera 12 (Post-doc)	S. Cherry 12 (Stud.)	
4	CNRS-CPT	24	–		T. Hambye 18 (Post-doc) P. Talavera 6 (Post-doc)	
5	UAB	24	–	J. Charles 12(Post-Doc) L. Girlanda 3(Post-Doc)	G. Garbarino 14 (Post-Doc)	
6	UVEG	24	–	L. Scimemi 24(Post-doc)		
7	UWIEN	24	–	G. Müller 13 (Post-doc)	V. Cirigliano 12 (Post-doc)	
8	DESY-ZEU	36	–	G. Venanzoni 20 (Post-doc)	S. De Falco 16 (Post-doc)	
9	UHELS	36	–	G. Amoros 24 (Post-doc) A. Polosa 24 (Post-doc)		
10	UBERN	24	–	A. Rusetsky 24 (Post-doc)		
Total	–	276	60	247	107	

Table 4: Status of EURODAPHNE Training Plan, PD=Post-doc, S=Student

the contract have been offered to young researchers and have been accepted. We therefore feel confident that it is in our possibilty to fulfill completely the network training obligations.

C.2 Training Programme

The training programme has been carried through according to the plan described in the project plan. The training program is articulated into three main modules:

Structure

- Training at the node by the scientist in charge
- Training through participation to network meetings
- Training through yearly attendance of the LNF Spring School

The young researchers working at the nodes have regular exchanges with their supervisors and have thus the possibilty to interact with leaders in their field. As an example, we note the case of the young post-doc in Oxford, who has had the privilege to work and study with Prof. Richard Dalitz, a member of our network, whose contribution to high energy physics is known by heart by any physics student in the world.

The young researchers are also given many opportunities to meet with the other scientists working on the same project or with the network as a whole. In particular, the three topical meetings, on Scalar Meson Dynamics, Hadronic Atoms and Measurement of the Hadronic Cross-section, held respectively in Durham, Bern and Frascati, have exposed the young scientists working on a given subject to the most advanced research on that particular research item. These meetings display the complementarity of the partners and have often resulted in new collaborations, as one group from one node is made aware of the advances of the other ones. Such has been the case for some recent work on ϕ-decays started by the Barcelona group and completed together with the Frascati group. In addition, in the three Collaboration Meetings held since the beginning of the Contract, the young researchers have been requested to present their work to the entire network, thus enabling them to assess their work in comparison with all the other young people and in front of all the senior members. Both the topical meetings as well as the Collaboration meetings are held in different european countries, to stress the internationality of the network and to provide for more exposure of the young people to the international community. Indeed, apart from the first meeting held in Frascati after the start of the contract, the other two Collaboration Meetings have been held respectively in Paris and in Granada.

Topical Meetings

Comple-mentarity

Collabo-ration Meetings

Interna-tionality

In addition to the above, all the young people of the Collaboration are expected to participate to the annual Spring School, to whose organization a special effort is dedicated by the Coordinator with the advice of members of the Executive Committee. The School is partly financed by INFN and is always held in Frascati. This works towards forming a special bond between the young people, most of whom have now known each other for sometime. Often, the new recruits for the network fellowships are chosen after their having participated to the School, which is international and widely advertized through Europe. The lecturers are chosen among European and American leaders of the field, special effort is placed on widening the scope of the School so as to expose the students to more than one subject. During the School, a meeting with the students allows for criticism and improvements for the year to follow. The program of the School during the last two years is appended to this report.

Spring School

Special bond

Interna-tional lecturers

Criticism

C.3 Factual Information on the Young Researchers

In the next Table 5, for each young researcher appointed with network funds, we show the following information: name, nationality, age at time of appointment, start and likely end date of appointment, cathegory of researcher (post-doc, pre-doc mentioning if undertaking PhD studies) scientific speciality, place of work, country of work, and whether the researcher had previously worked or studied at another network partner.

Table 5: Factual Information on Young Researchers

Name	Nationality	Age at appointment	Start of appointment	End of appointment	Post (PD) or pre-doc (ST)	Speciality	Place and Country of work	Previous exp. with network
Gudrun Hiller	De	31	1-10-98	30-9-99	PD	P01	LNF It	None
Rafel Escribano	Es	29	1-10-99	30-9-01	PD	P01	LNF It	Student UAB
Hannes Pichl	Au	28	1-03-00	28-2-01	PhD ST	P01	LNF It	Student Vienna
Kamel Behaddou	Fr	24	1-10-98	31-12-99	MSc ST	P01 UK	Durham	Student Paris
Gianni Garbarino	It	29	1-01-00	30-06-00	PD	P01	Oxford UK	Student Torino
Fulvia De Fazio	It	30	1-12-99	30-9-01	PD	P01	Durham UK	None
Pere Talavera	Es	32	1-5-00	30-4-01	PD	P01	Paris Fr	Lund UAB PhD
Jérôme Charles	Fr	27	1-12-99	30-11-00	PD	P01	UAB Es	Student Paris
Luca Girlanda	It	27	1-07-00	30-09-00	PD	P01	UAB Es	UB PD Paris
Gianni Garbarino	It	30	1-09-00	31-10-01	PD	P01	UB Es	Oxford Node
Ignazio Scimemi	It	30	1-11-99	30-10-01	PD	P01	Valencia Es	None
Guido Müller	De	31	1-11-98	15-12-99	PD	P01	Vienna Au	None
Graziano Venanzoni	It	30	1-01-99	30-08-00	PD	P01	Karlsruhe De	LNF Student
Gabriel Amoros	Es	27	1-11-98	31-10-00	PD	P01	Lund Se	Valencia PhD
Antonello Polosa	It	27	1-12-99	30-11-01	PD	P01	Helsinki Fi	None

D - Sketches of the Young Researchers

D.1

In the following, for each of the young researchers who will present their experience at the Mid-Term Review Meeting, a description of the young researchers scientific background, of his responsabilities in the network and of his experiences (positive and negative) to date, is presented. These sketches have been written by the young researchers themselves, and show their diverse backgrounds and experiences.

Rafel Escribano : INFN-LNF Laboratori Nazionali di Frascati

My personal engagement with the EuroDaphne Contract started the 1st of October when I arrived at the Laboratori Nazionali di Frascati (LNF) as an EuroDaphne postdoc. My scientific background has been the following: Ph. D. Degree with the thesis dissertation *Phenomenological Applications of Effective Lagrangians*, June 1996 (Universitat Autònoma de Barcelona); Sept. 96–Aug. 97, Assistant Professor (Universitat Autònoma de Barcelona); Sept. 97–Sept. 99, Chercheur IISN (Université Libre de Bruxelles) under the supervision of Prof. J.-M. Frère; Oct. 99–Sept. 01, EuroDaphne TMR postdoc (INFN-Laboratori Nazionali di Frascati) under the supervision of Prof. G. Pancheri.

SCIENTIFIC BACKGROUND

Since my engagement with the EuroDaphne Contract , I have been working on the following topics: the temperature dependence of the η and η' meson masses within the framework of $U(3)_L \times U(3)_R$ chiral perturbation theory; the theoretical prediction for the value of the ratio $R \equiv BR(\phi \to K^+K^-)/BR(\phi \to K^0\bar{K}^0)$; the effect of first order electromagnetic radiative corrections on the decay $\eta \to \pi^+\pi^-\pi^0$; the study of a proper definition of the mass and width of a scalar resonance; the rôle played by chiral loops and the $a_0(980)$ scalar resonance in the $\phi \to \pi^0\eta\gamma$ radiative decay;

RESPONSABILITIES

My personal experience within the EuroDaphne Collaboration has been very positive. I would like to emphasize, in particular, the excellent companionship among the people of the contract, the goodness of the EuroDaphne Meetings and the wide possibility of traveling and contact between the different nodes.

PERSONAL EXPERIENCE

Hannes Pichl : INFN-LNF Laboratori Nazionali di Frascati

For almost 6 months I have been staying here in Frascati as a predoc within the EuroDaphne collaboration.

SCIENTIFIC BACKGROUND

My activities cover the following topics: I studied the decay $K_L \to \pi^+\pi^-e^+e^-$ within the framework of Chiral Perturbation Theory (ChPT). The calculation was motivated by the possibility of extracting the numerical value of an unknown combination of coupling constants. Recent measurements of the magnetic part of the decay amplitude were taken into account and thus experimental input was included that had not been considered before in previous papers on a related subject. The decay $K^+ \to \pi^+\pi^0e^+e^-$ was calculated in ChPT again. This particular decay is interesting because of the decay width in general and the combinations of weak counterterms which appear in the amplitude. These two decays could be used to try to fix the numerical values of some important constants of the counterterm lagrangian (of course only if the decays are measured); My recent activities are writing my PhD thesis and preparing a second paper. A first paper on the extraction of the couplings has just been finished.

RESPONSABILITIES

What concerns my experiences with the network, or more precisely the node in Frascati, I have to say that I found an atmosphere of friendship and help at the LNF, which stimulates one's work and eager. I found a lot of people with whom I can discuss questions on physics and who are interested in my work and I am enjoying my stay here very much.

PERSONAL EXPERIENCE

Fulvia De Fazio : UKRAL Rutherford Appleton Laboratory

I joined the EURODAΦNE Network in December 1999, when I started with a post-doctoral position at Durham University (U.K.). At that time my scientific background was mainly concerned with theoretical Heavy Quark Physics, though my interest was more generally projected towards the calculation of non perturbative hadronic quantities and of fundamental parameters of the Standard Model, such as the strange quark mass. SCIENTIFIC BACKGROUND

My scientific activity with the EURODAΦNE network has been for me a good occasion to broaden my scientific horizons, giving me the possibility to be involved also in the Physics of light particles, with special attention to the problems relevant for the DAΦNE experiment. The U.K. node was committed to study at first radiative ϕ decays. I had the opportunity to collaborate with the scientist in charge of the node, Prof. M.R. Pennington; we studied the decays $\phi \to \eta\gamma$, $\phi \to \eta'\gamma$ using the QCD sum rule method. The analysis was the subject of an article published in the Journal of High Energy Physics (JHEP **0007**, 2000, 051). The results were presented at the Conference "Particle Physics 2000" (Edimburgh, April 2000) and at the 2000 LNF Spring School (Frascati, May 2000) and are included in the Proceedings. My work is going on with the analysis of other radiative ϕ decays, which will allow to establish better the nature of particles such as the $f_0(980)$. RESPONSABILITIES

I have to say that my experience to date is definitely positive, also because it allowed me to meet a number of scientists of the network. It has also contributed to my personal growth, since I came in touch with the English style of life, quite different from the previous environments I was used to. The EURODAΦNE meetings are organized in a friendly and stimulating atmosphere, which makes the establishment of collaborations and the contacts among the various nodes particularly simple and pleasant. I took part to date to the Conference DAΦNE 99 in November 1999 in Frascati, to the Collaboration Meeting in Granada, in February 2000, and to the Spring School in Frascati, which was particularly instructive mainly because of the pedagogical nature of many talks. PERSONAL EXPERIENCE

Pere Talavera : IN2P3-CNRS Orsay, Paris

I have been only, in a direct manner, recently involved in the Daphne collaboration although, almost since I started my PhD, I work in a related physics area. SCIENTIFIC BACKGROUND

Mainly I have worked in low energy physics using an effective approach. There has been several arena to focus: rare eta decays, photon-photon colision in the very first steps in the subject. Continuing with some projects related directly with Daphne experiments: radiative corrections to K_{l3} form-factors, K_{l4} decay at next-to-ext-to leading order. Nowadays I continue working in the same kind of physics considering radiative corrections, chiral phase transitions depending on the flavour number and some next-to-next leading corrections. RESPONSABILITIES

As I said my relation with the Eurodaphne network has only started three months ago. I consider that is not a enough long period to judge. But I have to say that I have collaborated with some of its members previously. From the human point of view they are streanly nice. while from an academic point I consider them relevant in the area. I have also had the benefit to assist to two workshops: Barcelona and Granada. Both of them well organized. PERSONAL EXPERIENCE

Jerome Charles : UAB Universitat Autònoma de Barcelona

I entered the Eurodaphne network as a postdoc at the Barcelona node in December 1999. SCIENTIFIC BACKGROUND

I already had contacts with the network while I was preparing my PhD thesis in Orsay and collaborating with Luis Oliver. Meanwhile, I was accepted at the French CNRS for a permanent position at CPT-Marseille. When I return to France in December 2000, I will recover this position.

Responsabilities

I am primarily working on B-physics: the phenomenology at the Daphne experiment represents for me a new field of research, where I still have a lot of to learn. The network provides me with the possibility of completing my education, by making me meet the best experts in this interesting subject. Since I am an Eurodaphne postdoc, I have pursued various things that were in progress before leaving: the study of exclusive semileptonic B-decays. In Orsay we had derived a set of theoretical constraints on these decays in a specific kinematical limit. Since then, other people have calculated radiative corrections to this limit. I am currently investigating how this formalism, which is not completely understood yet, could be improved in order to find new constraints; the study of the violation of the CP-symmetry in rare B-decays. Motivated by recent experimental and theoretical results, I am trying to understand how the factorization in the heavy quark limit could be used to extract the CP-odd phases. With Luis Oliver, I am also reviewing the problem of the discrete ambiguities (multiple solutions) in determining theses phases. I would like to stress that B-physics and K-physics, as will be done at Daphne, are fully complementary: they pursue the same goal, testing the Standard Model especially in the quark mixing sector, and often use similar theoretical tools.

Personal Experience

Last but no least, this Eurodaphne position offers me an unique opportunity for living in the very nice town of Barcelona, and learning one of the most common languages in the world which is Spanish. I also have to say that I have received a very friendly greeting at UAB, which is a quite important point when living abroad. To conclude, my experience of the network is very positive.

Gianni Garbarino : UAB Universitat Autònoma de Barcelona

Scientific Background

I spent 6 months (since 1st January 2000) at the university of Oxford (under the Durham node) as an EuroDaphne post–doc. During this period I had the pleasure and honour to work with Professor R. H. Dalitz. The research activity during my PhD (University of Turin, 1996–1999) concerned the evaluation, within the polarization propagator method, of the weak decay widths of Λ–hypernuclei.

Responsabilities

During the post–doc period I have been engaged in two different topics: I studied, within the phenomenological model of Block and Dalitz, the validity of the $\Delta I = 1/2$ rule in the $\Lambda N \to NN$ process. Due to the low precision of experimental data, a possible violation of this rule can be neither proved nor excluded at present with sufficient accuracy: a pure $\Delta I = 1/2$ transition amplitude is excluded at 40% confidence level [*The* $\Delta I = 1/2$ *rule in non–mesonic weak decay of* Λ*–hypernuclei*, W. M. Alberico and G. Garbarino, Phys. Lett. **B 486** (2000) 362]; Then I studied the predictions of local realistic theories for a pair of correlated and non–interacting neutral kaons originated in the decay of the ϕ–meson. The problem has been treated both by employing Bell-type inequalities and by evaluating directly the local realistic expectation values. The results agree with the Bell's theorem: any local hidden–variable model for the $K^0\bar{K}^0$ pair is incompatible with some statistical prediction of quantum mechanics. A correlation test discriminating between local realistic theories and quantum mechanics could be performed at the Frascati Φ-factory in the near future. Indeed, our results show that the incompatibility between local realism and quantum mechanics can reach, in particular situations, the level of 20–30%. A first version of the manuscript concerning this work will be ready in few days.

The experience has been very interesting and fruitful both on the scientific and human side. In particular, I thank Prof. Dalitz for communicating me the interest on problems related to the foundation and interpretation of quantum mechanics. PERSONAL EXPERIENCE

Luca Girlanda : UAB Universitat Autònoma de Barcelona

I have been involved in the Eurodaphne network since the beginning of my Ph.D. (1996-1999), at the Institut de Physique Nucléaire of Orsay, as member of the Paris node, and during the year 2000 at the Institut de Física d'Altes Energies, as a postdoc in the Barcelona node. Here I was funded as an Eurodaphne postdoc during the period July-September 2000. SCIENTIFIC BACKGROUND

My research activity has been mainly focused on the study of the mechanism of Spontaneous Chiral Symmetry Breakdown in QCD, in particular on the phenomenological determination of the quark condensate. The technical tool suited to this goal is the generalized version of Chiral Perturbation Theory, which I contributed to develop in the case of SU(2)×SU(2) chiral symmetry. This effective theory has been applied to find signatures of the amount of quark-antiquark condensation in $\pi\pi$ scattering and hadronic τ decays in the threshold region. Of direct interest to the Daphne physics program is the correspondence between low-energy $\pi\pi$ scattering observables, accessible through K_{e4} experiments, and the quark condensate, which I computed including the next-to-next-to-leading logarithmic corrections. On a more formal ground, I was involved in the study of the role of the number of massless flavors for the mechanism of Chiral Symmetry Breakdown. RESPONSABILITIES

I have enormously benefited from being part of the Eurodaphne network, both from the scientific and human point of view. In particular I found very useful and stimulating the Collaboration meetings, often held jointly with the LNF Spring School, in which I repeatedely had the opportunity to present and discuss my results with many experts in the field. They were also the occasions for creating pleasant, fruitful and hopefully long-lasting relations with the people of the network. PERSONAL EXPERIENCE

Ignazio Scimemi : UVEG University of Valencia

I have joined the collaboration in november 1999. The main part of my background is constituted by the study of Kaon and B–physics. This field is interesting both in the contest of the Standard Model Physics for the comprehension of the non–perturbative aspects of QCD, both for the study of new physics. In fact traces of particles not yet discovered can be recovered, for instance, studying CP–violating signals. SCIENTIFIC BACKGROUND

The activity that has been worked out, concerns several of the topics of this area. In the first part of the year it has been performed a study on Heavy Baryons. Their study is very interesting as a test of Heavy hadron chiral perturbation theory. Both decay modes and magnetic moments of the baryons have been studied and symmetry properties have been worked out. We have then performed a complete study of ϵ'/ϵ in the Standard Model. It has been noted that a careful analysis which includes correctly final state interaction can provide, with reasonable precision, a description of this observable which can account for the experimental results obtained by NA48 and KTeV. The theoretical background necessary for this analysis is constituted by large N_c expansion and chiral perturbation theory. Our analysis has been able to disentangle all the various contributions and to correctly account for all of them. ϵ'/ϵ is a fundamental quantity as it accounts for direct CP–violation and phases present in the model. So, in principle it can receive also significant contribution from New Physics Sources. A study of this hypothesis has been performed in particular RESPONSABILITIES with SUSY extensions of the Standard Model. Stronger constraints on these models can so be obtained and this has strong consequences on the contributions to Rare Kaon Decays predicted in some of them. A more complete picture of all contributions involving the first two generation of particles (and s–particles) can now be accounted. The relations of this also with B–physics, nuclear electric dipole moments, etc. are (and will be) also studied.

Personal Experience

Concluding, the experience with the network has been very positive. The subject of the work undertaken are fundamental for the comprehension of Nature and the working environment is very competent and pleasant.

Gabriel Amorós : UHELS University of Helsinki (Lund subnode)

Scientific Background

At the moment and with the experience of my period in the network, I increased my knowledge in the pseudoscalar sector of the standard model, in the range of energies used in the Frascati laboratory, with special attention to Chiral Perturbation Theory (CHPT). Within the projects where I was involved I obtained large experience with higher order corrections in general and with effective lagrangians in particular.

Responsabilities

Since my incorporation to the network in November 1998 as a young postdoctoral researcher, I have been envolved in several projects to develop higher order corrections for several Green Functions inside CHPT, in collaboration with J. Bijnens (Lund) and P. Talavera (Paris). In particular we developed two-loop results for the Green Functions in a complete three-flavour framework. Next we used this result to obtain a higher order result for the decay $K \to \pi\pi e\nu$. Our next step in progress is to obtain a two-loop result for the $K \to \pi e\nu$ decay using similar techniques.

Personal Experience

The experience within this team has been and is very positive and also necessary for the kind of projects involved. It is also interesting as a environment to share knowledge and experience important for the evolving scientific career. As a member of the network I also participated in several schools, Workshops and meetings (Frascati-1999, Frascati-2000, Bern-1999, Granada-2000) with contributions in all of them and as an opportunity to communicate the result besides the published papers.

Antonello Polosa : UHELS University of Helsinki

Scientific Background

During my first 8 months spent at the University of Helsinki as a EuroDaphne post-doc I've accumulated a considerable amount of interesting experiences that by sure have enriched and widened my perspectives and attitudes towards research. First of all, I've met the extreme kindfullness of Mikko Sainio and Nils Törnqvist that have done their best from the very beginning to make feel at home a southern man in Helsinki (with excellent results, since I'm already over-attached to this town).

Responsabilities

The scientific collaboration with Nils Törnqvist has been up to now a pleasurable meeting of my short experience in heavy meson physics with his long and solid knowledge of hadron physics expecially in its phenomenological aspects. The initial difficulties I met in understanding the apparently 'old fashioned' language of dispersion relations, of some peculiarities of Linear Sigma Models and many other topics of what nowadays is classified as low energy hadron physics, has switched a certain interest in 'filling the gap', that now I understand as a positive circumstance.

Personal Experience

Our collaboration has given results that I consider interesting and new. Moreover I've been allowed to maintain scientific contacts with my initial collaborators R. Gatto, G. Nardulli and A. Deandrea at Cern, Bari U. and Cern and Lyon U. respectively. A recent preprint we have worked to carries the names of Gatto, Nardulli, Törnqvist and myself, to witness also the possibility of 'enlarged' and fruitful collaborations.

Akaki Rusetsky: UBERN University of Bern

During my stay at the Institute for Theoretical Physics, University of Bern as an EURODA-ΦNE post-doctorand, I have been engaged in the investigation of the properties of the bound states (hadronic atoms) in ChPT. The experiments on hadronic atoms that are held at CERN, PSI, LNF-INFN, KEK, etc, enable one to directly measure the strong scattering amplitudes at threshold and thus provide an extremely valuable information about strong interactions at low energy. In particular, the DEAR experiment at DAΦNE plans to measure the energy level shift and lifetime of the $1s$ state in K^-p and K^-d atoms. It is expected that this will result in a precise determination of the $I = 0, 1$ S-wave scattering lengths. It will be a challenge for theorists to extract from this new information a more precise value of e.g. the kaon-nucleon sigma term and of the strangeness content of the nucleon. Scientific Background

In order to perform the above mentioned tests of QCD at low energy, one needs a consistent theory of the hadronic atoms which would allow to perform the calculations of the observable characteristics of this sort of systems in the precision that matches the accuracy of the experimental measurements. The investigations which at present I am carrying out in collaboration with Prof. J. Gasser, are aimed at the solution of this problem. Namely, in the approach based on the non-relativististic effective Lagrangian approach and ChPT, a complete theory of the $\pi^+\pi^-$ atom decay which is recently studied by DIRAC collaboration at CERN, was constructed. Within the same approach, the energy-level shift of the π^-p atom that is measured at PSI, was studied. The theoretical investigations of other hadronic bound states are foreseen. Responsabilities

My experience with the EURODAΦNE network is entirely positive. I find that it provides every opportunity to carry out the fruitful research work. Personal Experience

E - Network Financing

In Table 6 we compare the estimated expenditure as of August 31st, 2000 of each network partner with the allowable costs foreseen in the the contract. We also estimated a breakdown of the total expenditure of the network into the cost categories A, B, C and D.

We see from this table that the network has spent 46% of its assigned funds. In the young researchers category, (A), the expenditures has been 43%, a figure which reflects the fact that most of the young people appointments have started during the second year of operation. On the basis of the training plan previously discussed, we now expect all of our assigned budget for appointment of young reearchers to be spent by the end of the contract. Overal expenditures for networking is above 50% level and thus in agreement with our planning.

Concerning the expenses of individual nodes, one may notice some anomalies, notably in the case of the Marseille node, Participant N. 4, whose expenses are only 10% of the assigned funds. This is ascribable to a delay in hiring, since the young researcher originally appointed found a position outside the field of physics and cancelled his committment. This cancellation upset the planning of the Marseille node. However, hiring is now going to be fulfilled through appointment of Thomas Hambye and Pere Talavera, and this anomaly will disappear very soon.

Table 6: Assigned funds and funds spent as of Sept. 1, 2000 in KEURO

N^o	A	A_{now}	B	B_{now}	C	C_{now}	D	D_{now}	Tot	Tot_{now}
1	118	61	48	26	2	0.6	32	18	200	105.6
2	127	68.4	35	20	9	0.1	34	17.1	205	105.6
3	81	15.2	25	14.3	4	2	17	8.6	127	40.1
4	94	0	20	5.5	4	3.2	18	1.5	136	10.2
5	60	16.4	25	26	19	3.7	16	8.9	120	55
6	60	18	25	20	4	0	13	8	102	46
7	91	51	21	7.3	4.8	0	20	10.3	137	68.6
8	103	55.2	15	6	21	14.8	16	10.6	155	86.6
9	115	74	16.5	9	8.5	6	28	12	168	101
Total	849	359.2	230.5	134.1	76.3	30.4	194	95	1,350	618.7

F - Proposed Revisions to the Contract

We think that the project is proceeding according to our original plan and do not see the need for any revision of the Contract.