$K_{\ell 4}$ AT TWO-LOOPS AND CHPT PREDICTIONS FOR $\pi\pi$-SCATTERING

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We present the results from our two-loop calculations of masses, decay-constants, vacuum-expectation-values and the $K_{\ell 4}$ form-factors in three-flavour Chiral Perturbation Theory (CHPT). We use this to fit the L_i^r to two-loops and discuss the ensuing predictions for $\pi\pi$-threshold parameters.

We present the main results of a rather long program of two-loop calculations in three flavour CHPT in the meson sector. The Lagrangian at lowest order p^2 has two-parameters and two quark masses. In practice, in the isospin limit, this leads to F, $B_0\hat{m}$ and $B_0 m_s$ as the three free parameters. At order p^4 there are an additional[1] 10 and at order p^6 there are[2] 90. An overview of the calculations at two-loops in the two-flavour sector can be found in [3], presented in the previous Chiral Dynamics meeting. Since then the $\pi\pi$ scattering[4], the vector and scalar form-factor[5] and the expressions in terms of the p^6 low-energy constants have been published[6]. In the three-flavour sector the generalized double-log contributions were found to be large[7]. This prompted us to start our program so a major refit of CHPT parameters to two-loop order would be possible. Other three flavour p^6 work is in Ref.[12].

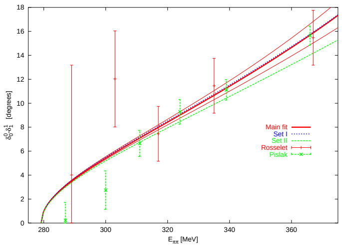
In Ref.[8] we calculated the VV and AA two-point functions to two-loop order and in Refs.[9,10] the $K_{\ell 4}$ form-factors and the vacuum-expectation-values. Future work is concentrating on isospin violating effects.

There is a large number of parameters that needs determination. We have been forced to use assumptions to estimate the p^6 constants but checked that varying them within a factor of two didn't change results significantly. In addition we used $L_4^r = L_6^r = 0$ and $m_s/\hat{m} = 24$ as theoretical input. Experimental input is F_π, F_K/F_π, M_π, M_K, M_η and from $K_{\ell 4}$, $F(0)$, $G(0)$ and the slope λ. The resulting fit for the L_i^r is quite stable. Fit results without the η' contribution in the p^6 estimate are in [9] and with it in [10]. The main results and the variation with some of the input are shown in Fig. 1. Notice the variation with $K_{\ell 4}$ input in fit 9. We look forward to more $K_{\ell 4}$ data that

Figure 1. The fit of L_i^r described in the text. We have shown some of the input variations used.

	Main Fit	fit 2	fit 8	fit 9
$10^3\ L_1^r$	0.52±0.23	0.53	0.63	0.65
$10^3\ L_2^r$	0.72±0.24	0.73	0.73	0.85
$10^3\ L_3^r$	−2.70±0.99	−2.71	−2.67	−3.27
$10^3\ L_5^r$	0.65±0.12	0.62	0.51	0.60
$10^3\ L_7^r$	−0.26±0.15	−0.20	−0.25	−0.26
$10^3\ L_8^r$	0.47±0.18	0.35	0.44	0.48
changed		$m_s/\hat{m}$	μ	$g(0)$
quantity		26	1.0	4.93

Figure 2. The results for $\pi\pi$ scattering and the new data (Pislak).



would add more precision, especially in the value of the slopes for F and G, to have more redundancy in the input. The excellent prediction for $\pi\pi$ is shown with data, including the new BLN data[11], in Fig. 2.

Acknowledgments

Work partially supported by the EU TMR Network EURODAPHNE (Contract No. ERBFMX-CT98-0169) and by the Swedish Science Foundation.

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