LEPTOQUARK SIGNAL FROM GLOBAL ANALYSIS

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Data from HERA, LEP and the Tevatron, as well as from low energy experiments are used to constrain masses and Yukawa couplings for scalar and vector leptoquarks in the Buchmüller-Rückl-Wyler effective model. Some leptoquark models are found to describe the existing experimental data much better than the Standard Model. Increase in the global probability observed for models including S_1 or $\tilde{V}_\circ$ leptoquark production/exchange corresponds to more than a 3σ effect.

New result on the atomic parity violation (APV) in caesium[1] and the unitarity of the CKM matrix,[2] as well as recent LEP2 hadronic cross-section measurements[3] indicate possible deviations from the Standard Model (SM) predictions. Observed deviations can be described by the electron-quark contact interactions with an effective mass scale of the order of 13 TeV.[4] Exchange of the leptoquark type objects has been proposed as a possible explanation for these effects.

The global leptoquark analysis[5] combines relevant data from HERA, Tevatron and LEP2, results from low-energy eN, μN and νN scattering experiments, constraints on the CKM matrix unitarity and electron-muon universality, and the APV measurements. The Buchmüller-Rückl-Wyler model[6,7] is used for general classification of the first-generation leptoquarks. The analysis is based on the global probability function $\mathcal{P}(\lambda_{LQ}, M_{LQ})$, which describes the probability that the data come from the leptoquark model with coupling λ_{LQ} and mass M_{LQ}. It is defined in such a way that the SM probability $\mathcal{P}_{SM} \equiv 1$.

In the limit of very high leptoquark masses, constraints on the coupling to the mass ratio were studied using the contact interaction approximation.[8] The best description of the data is obtained for the S_1 and the $\tilde{V}_\circ$ leptoquark models with $\lambda_{LQ}/M_{LQ} \sim 0.3\ \mathrm{TeV}^{-1}$. Observed increase in the global probability corresponds to more than 3σ deviation from SM. The effect is mostly resulting from the new data on APV in caesium, but is also supported by other measurements.

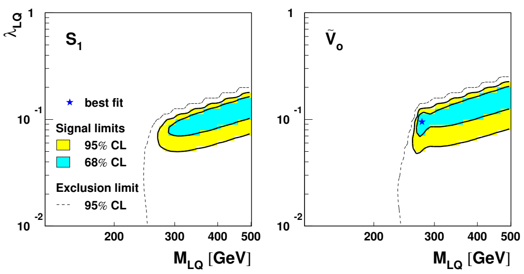

Figure 1. Signal limits on 68% and 95% CL for S_1 and $\tilde{V}_\circ$ leptoquarks. Dashed lines indicate the 95% CL exclusion limits. For the $\tilde{V}_\circ$ model a star indicates the best fit parameters. For the S_1 model the best fit is obtained in the contact interaction limit $M_{LQ} \rightarrow \infty$.

Constraints on the leptoquark couplings and masses were studied also for finite leptoquark masses, with mass effects correctly taken into account. Shown in Figure 1 are the 95% exclusion limits (corresponding to the global probability equal to 5% of the SM probability: $\mathcal{P}(\lambda_{LQ}, M_{LQ}) = 0.05$) as well as the 68% and 95% CL signal limits (corresponding to $\mathcal{P}(\lambda_{LQ}, M_{LQ}) = 0.32\ \mathcal{P}_{max}$ and $0.05\ \mathcal{P}_{max}$, respectively) for the S_1 and the $\tilde{V}_\circ$ leptoquark models. The best description of the data for the $\tilde{V}_\circ$ model is obtained for $M_{LQ} = 276 \pm 7$ GeV and $\lambda_{LQ} = 0.095 \pm 0.015$. Maximum at the low $\tilde{V}_\circ$ leptoquark mass results from the excess of high Q^2 NC DIS

Table 1. Results of the global leptoquark analysis: the 95% CL exclusion limits on the leptoquark coupling to the mass ratio λ_{LQ}/M_{LQ} (upper limit) and the leptoquark mass M_{LQ} (lower limit), the coupling to the mass ratio $(\lambda_{LQ}/M_{LQ})_{max}$ resulting in the best description of the experimental data and the corresponding model probability $\mathcal{P}_{max}$, and the 95% CL signal limits on λ_{LQ}/M_{LQ} and M_{LQ}, for models with $\mathcal{P}_{max} > 20$.

Model	95% CL excl. limits		best description		95% CL signal limits	
	$\frac{\lambda_{LQ}}{M_{LQ}}$ TeV^{-1}	M_{LQ} GeV	$\left(\frac{\lambda_{LQ}}{M_{LQ}}\right)_{max}$ TeV^{-1}	$\mathcal{P}_{max}$	$\frac{\lambda_{LQ}}{M_{LQ}}$ TeV^{-1}	M_{LQ} GeV
$S^L_\circ$	0.27	213				
$S^R_\circ$	0.25	242				
$\tilde{S}_\circ$	0.28	242				
$S^L_{1/2}$	0.29	229				
$S^R_{1/2}$	0.49	245	0.32 ± 0.06	35.8	0.09–0.44	258
$\tilde{S}_{1/2}$	0.26	233				
S_1	0.41	245	0.28 ± 0.04	367.	0.15–0.36	267
$V^L_\circ$	0.12	230				
$V^R_\circ$	0.44	231	0.28 ± 0.07	11.7		
$\tilde{V}_\circ$	0.52	235	0.34 ± 0.06	122.	0.16–0.46	259
$V^L_{1/2}$	0.47	235	0.30 ± 0.06	31.7	0.08–0.42	254
$V^R_{1/2}$	0.13	262				
$\tilde{V}_{1/2}$	0.47	244	0.30 ± 0.07	14.8		
V_1	0.14	254				

events observed in the 1994-97 HERA data.

Table 1 summarizes the results of the global leptoquark analysis.[5] For all models the 95% CL exclusion limits are given, both for λ_{LQ}/M_{LQ} (upper limit) and for M_{LQ} (lower limit). For leptoquark models which describe the existing experimental data better than SM the maximum value of the global probability $\mathcal{P}_{max}$ and the corresponding coupling to the mass ratio $(\lambda_{LQ}/M_{LQ})_{max}$ are included (in the contact interaction approximation). 95% CL signal limits for λ_{LQ}/M_{LQ} and M_{LQ} are given for models with $\mathcal{P}_{max} > 20$.

If the observed leptoquark signal is real it should become clearly visible in future colliders.[9]

This work has been partially supported by the Polish State Committee for Scientific Research (grant No. 2 P03B 035 17).

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