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e^+e^- Annihilation into Hadrons at LEP2 in the Presence of the Anomalous DESY Positron-Jet Event Phenomenon

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Abstract

We discuss the allowed parameter regime in the coupling-mass plane implied by the existing LEP2 data on $e^+e^- \to hadrons$ at 172.3 GeV for the leptoquark interpretation of the anomalous DESY positron-jet events for four different models of the leptoquark charges and chiral couplings to quarks, for both a loose cut on s'/s and a tight cut on s'/s. We find that this interpretation of the DESY phenomenon is still consistent with the LEP2 data although, for vector leptoquarks, a significant regime of the relevant parameter space is already excluded.

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Recently, the H1 and ZEUS Collaborations have reported [1,2] an anomalous amount of high Q^2, high x_{Bj} events in the deep inelastic e^+p scattering at HERA. In this paper, we investigate the consequences in the LEP2 process $e^+e^- \rightarrow hadrons$ of the existence of the DESY phenomenon if it is interpreted as the exchange of a spin one or zero object in the s-channel in the reduced $e^{+}\overset{(}{q}\overset{)}{}$ parton level process at HERA. For, by the crossing symmetry, this object, whatever it may be, should then be exchanged in the t(u)-channel in the LEP2 e^+e^- annihilation and the current agreement level between the SM (Standard Model) and the LEP2 data on $e^+e^- \rightarrow hadrons$ should already place some constraints on the allowed couplings and mass ranges. In our work, we elucidate some of these constraints. We note that preliminary constraints on a scalar leptoquark from LEP2 e^+e^- annihilation data have already been presented by S. Kamamiya in Ref. [3]. We will see that our analysis of the vector and scalar cases yields results consistent with the latter.

For definiteness, we shall call this spin one or zero object a 'leptoquark', since according to Ref. [4], it has a mass $\sim 200GeV$ and a width $\lesssim$ 2.2 GeV. We stress as it has been already done in Ref. [5] that as long as the couplings of this object, which may be composite or elementary, are sufficiently chiral and diagonal in flavor and zero on diquark fields, it is not in contradiction with any known physical requirement. Thus, we proceed entirely phenomenologically and try to answer the very definite question as to whether the LEP2 data are consistent with a vector or scalar 'leptoquark' explanation of the DESY data. See Refs. [6–10] for related but independent analyses of the DESY data and its possible interpretation. We recall that the scalar leptoquark and the susy scalar quark are, from the point of view of our analysis, essentially synonymous [6–8].

More specifically, in this brief note we record the differential cross section for $e^+e^- \rightarrow \bar{q}q$ in the presence of the DESY leptoquark for two models of leptoquark charges. We have, for the quark elemental solid angle $d\Omega_q$ in the cms system,

$$\frac{d\sigma}{d\Omega_q} = \frac{1}{64\pi^2 s}|\bar{\mathcal{M}}|^2, \tag{1}$$

where the spin averaged squared matrix element, for the leptoquark charges $(\frac{5}{3}, \frac{2}{3})$ coupling to left-handed quarks (model (1)), is

$$\begin{aligned} |\bar{\mathcal{M}}|^2_{\{\frac{5}{3},\frac{2}{3}\}_L} = &\left|\frac{\delta_{S,1}g_X^2}{2D_X(t)} + \sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\ &+\left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\ &+\left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\ &+\left|\frac{\delta_{S,0}g_X^2}{4D_X(t)} + \sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 t^2, \end{aligned} \tag{2}$$

for the leptoquark charges $(\frac{5}{3},\frac{2}{3})$ coupling to right-handed quarks (model (2)), is

$$
\begin{aligned}
|\bar{\mathcal{M}}|^2_{\{\frac{5}{3},\frac{2}{3}\}_R} = & \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\
& + \left|\frac{\delta_{S,1}g_X^2}{2D_X(t)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\
& + \left|\frac{\delta_{S,0}g_X^2}{4D_X(t)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\
& + \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 t^2,
\end{aligned}
\tag{3}
$$

and, for the leptoquark charges $(\frac{4}{3},\frac{1}{3})$ coupling to left-handed quarks (model (3)), is

$$
\begin{aligned}
|\bar{\mathcal{M}}|^2_{\{\frac{4}{3},\frac{1}{3}\}_L} = & \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\
& + \left|-\frac{\delta_{S,1}g_X^2}{2D_X(u)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\
& + \left|-\frac{\delta_{S,0}g_X^2}{4D_X(u)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\
& + \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 u^2,
\end{aligned}
\tag{4}
$$

and, for the leptoquark charges $(\frac{4}{3},\frac{1}{3})$ coupling to right-handed quarks (model (4)), is

$$
\begin{aligned}
|\bar{\mathcal{M}}|^2_{\{\frac{4}{3},\frac{1}{3}\}_R} = & \left|-\frac{\delta_{S,1}g_X^2}{2D_X(u)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\
& + \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 t^2 \\
& + \left|\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)+a_\rho(q))(v_\rho(e)+a_\rho(e))}{D_\rho(s)}\right|^2 u^2 \\
& + \left|-\frac{\delta_{S,0}g_X^2}{4D_X(u)}+\sum_{\rho=A,Z}\frac{G_\rho^2(v_\rho(q)-a_\rho(q))(v_\rho(e)-a_\rho(e))}{D_\rho(s)}\right|^2 u^2,
\end{aligned}
\tag{5}
$$

where $S=0,1$ is the spin of the leptoquark X and $\delta_{a,b}$ is the Kronecker delta function and where we have defined the following kinematical and dynamical variables:

$$
\begin{aligned}
&D_X(u) = u - M_X^2, \quad M_X = 200\ GeV, \\
&D_Z(s) = s - M_Z^2 + i\Gamma_Z s/M_Z, \quad D_A(s) = s, \\
&v_Z(f) = \frac{1}{2}I_3 - Q_f \sin^2\theta_W, \quad a_Z(f) = \frac{1}{2}I_3, \\
&v_A(f) = Q_f, \quad a_A(f) = 0, \\
&G_Z = e/(\sin\theta_W \cos\theta_W), \quad G_A = e, \\
&g_X = (e/\sin\theta_W)(1+\delta), \\
&s = (p_1+q_1)^2,\ t\ =\ (p_1-p_2)^2,\ u\ =\ (p_1-q_2)^2,
\end{aligned}
\tag{6}
$$

where $\{p_1, q_1\}$ are the incoming e^+, e^- 4-momenta respectively and $\{p_2, q_2\}$ are the outgoing $\{\bar{q}, q\}$ 4-momenta respectively. Here, δ is unknown and is to be varied to see what the data will allow. I_3 is the usual weak isospin 3-component for fermion f and Q_f is its electric charge in units of the positron charge e. We have thus complied with the constraint from Refs. [5, 11, 12] that only quarks of a specific chirality should couple to any particular leptoquark.

The formulae presented above we have implemented into the KORALZ Monte Carlo [13] program. We have performed the technical tests of the matrix elements as implemented in KORALZ and compared them with analytical results on several approximated forms of the above matrix elements, e.g. for $Z+\gamma$ or only Z exchange excluded, and for the production angle θ such as $\cos\theta = 0, \pm\frac{1}{2}$. Agreement of 4-5 digits was always found. Later, QED and electroweak corrections were extended (to our X-exchange i.e. non s-channel Z, γ interaction) automatically, accordingly to the prescription identical to that, explained in Ref. [14]. In particular the discussion of uncertainties of QED corrections implementation presented there can be straightforwardly extended to the present case.

We stress that the leptoquark-quark-lepton vertices which we have assumed in eqs. (2-5), corresponding to the $U_1, \tilde{U}_1$, $\tilde{V}_2, V_2$, and U_3 spin 1 and R_2, $\tilde{R}_2$, S_1, $\tilde{S}_1$ and S_3 spin 0 examples in Ref. [5], are intended to be generic and not exhaustive: it is straightforward to include more general coupling scenarios into our KORALZ [13] calculational framework, should this become necessary. We point-out further that we may identify our spin 1(0) states in models (1-4) respectively with the corresponding charge and mass eigenstates formed from the states S_L,T, $\tilde{S}_R$, S_R, D_L,D_R and $\tilde{D}$ in the notation of Refs. [11, 12]; for, at scales $\sim$ 200 GeV, we expect the $SU_{2L}\times U_1$ electroweak symmetry to be broken with leptoquark states of the same charge and color mixed into the respective mass eigenstates and it is these mass eigenstates that we have used in (1). In other words, from the DESY data we we may have that $\bar{e}q$ resonates into the leptoquark X, $q = u, d$, models (1) and (2) with t-channel X exchange in $e^+e^- \to \bar{q}q$ and $F = 0$ in the language of Refs. [5,11,12], or that $\bar{e}\bar{q}$ resonates into the leptoquark X, $q = u, d$, models (3) and (4) with u-channel X exchange in $e^+e^- \to \bar{q}q$ and $F = -2$ in the language of Refs. [5, 11, 12], where F is the fermion number of X. For definiteness, we have assumed strong isospin symmetry for simplicity; it is trivial to relax this last assumption, should more data render this necessary. For completeness, we then record the interaction Lagrangian densities which

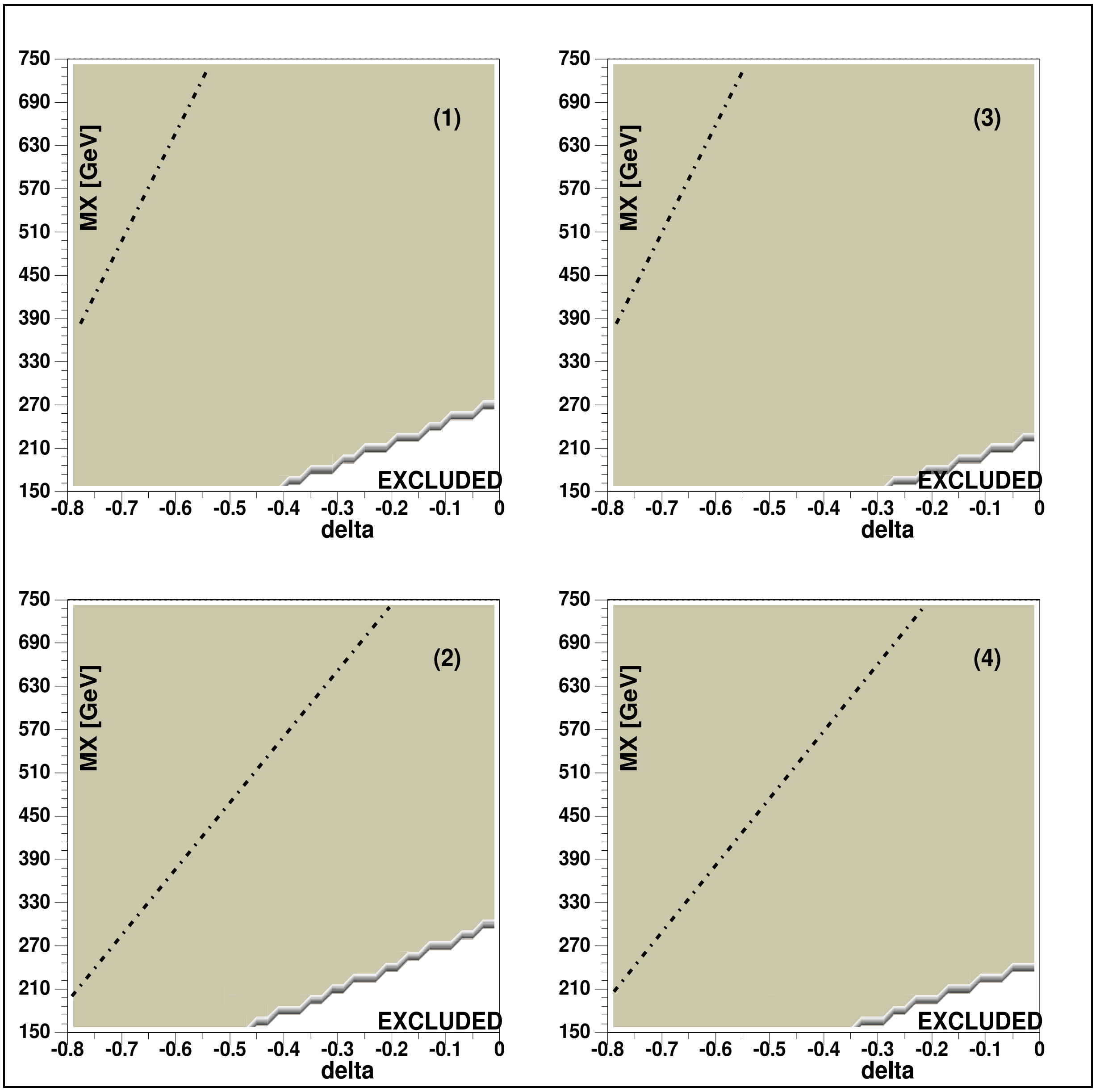

Figure 1: Exclusion plots at 95% CL for the hard cut $(s'/s)_{\min} \in (0.72, 0.81)$ implied by the LEP2 172.3 GeV data on $e^+e^- \to hadrons$ for the four vector leptoquark models described in the text: in plot (i) we give the excluded region of the $g_X - M_X$ plane for model (i) as described in the text, $i = 1, \cdots, 4$, with g_X given by δ via (6) and M_X in GeV. Dashed (dotted) line corresponds to limits of Ref. [11] for spin 1 as explained in the text.

we used to arrive at the results (2)–(5), for $S = 1$,

$$
\begin{aligned}
\mathcal{L}^{\{5/3,2/3\}}_{int,1,H} &= -\frac{g_X}{\sqrt{2}}\left(X^{(-5/3)\alpha}_{\mu}\bar{e}_H\gamma^{\mu}u^{\alpha}_H + X^{(-2/3)\alpha}_{\mu}\bar{e}_H\gamma^{\mu}d^{\alpha}_H + h.c.\right), \\
\mathcal{L}^{\{4/3,1/3\}}_{int,1,H} &= -\frac{g_X}{\sqrt{2}}\left(X^{(-4/3)\alpha}_{\mu}\bar{d}^{\alpha}_H\gamma^{\mu}e^{c}_{H'} + X^{(-1/3)\alpha}_{\mu}\bar{u}^{\alpha}_H\gamma^{\mu}e^{c}_{H'} + h.c.\right),
\end{aligned}
\tag{7}
$$

where here $H = L, R$, and H' denotes chirality opposite to H, i.e. $H' = L$, for $H = R$ and $H' = R$ for $H = L$. We have defined $\psi_{L(R)} = P_{L(R)}\psi$ as well as $\psi^c = C\bar{\psi}^T$ for all ψ, where T denotes transposition. The the chiral projections are here $P_L = (1-\gamma^5)/2, P_R = (1+\gamma^5)/2$ and C is the charge conjugation matrix in an appropriate representation. Thus, $\mathcal{L}^{\{5/3,2/3\}}_{int,1,L}$ describes the interactions used to derive the result (2), ... , and so on. The analogous formulas for $S = 0$ for $\mathcal{L}^{\{Q,Q-1\}}_{int,0,H}$ follow from those for $\mathcal{L}^{\{Q,Q-1\}}_{int,1,H}$ from the corresponding replacements *vector* $X \times$ *vector Dirac current* $\Leftrightarrow$ *scalar* $X \times$ *scalar Dirac current* in an obvious way so we do not list them explicitly.

In the Fig. 1, we exhibit the 95% CL exclusion plot in the g_X, M_X plane, for $S = 1$, which follows from comparing the cross sections in eqs. (1)–(5) as implemented in KORALZ [13] with the allowed deviation from the SM expectation, where we take the respective leptoquark to couple to the first generation only and we use the LEP2 data presented at the LEP Jamboree [3] to derive the allowed deviation $-0.0251\sigma_{SM} \leq \Delta\sigma \leq 0.119\sigma_{SM}$ for the tight cut[1] $(s'/s)_{\rm min} \in (0.72, 0.81)$ and the allowed deviation $-0.0103\sigma_{SM} \leq \Delta\sigma \leq 0.0613\sigma_{SM}$ for the loose cut $(s'/s)_{\rm min} \in (0.010, 0.015)$, both at 95% CL. Here, σ_{SM} is the respective SM cross section and $\Delta\sigma$ is the corresponding deviation allowed experimentally[2]. For the latter excluded region, we do not find any significant change over the limits that follow from the former excluded region, so we only consider the former one henceforth. Thus, for each of our four leptoquark models, charges (5/3,2/3) with left-handed (model 1) and right-handed (model 2) couplings to quarks and charges (4/3,1/3) with left-handed (model 3) and right-handed (model 4) couplings to quarks, we show the exclusion plots corresponding to the former (hard s'/s cut) 95% CL deviation interval just given, for $S = 1$. These are shown in Fig. 1, for the M_X range $[150\ GeV, 750\ GeV]$ and for the coupling range corresponding to $-0.8 \leq \delta \leq 0.0$ as defined in (6); for $S = 0$, we do find an excluded region in the parameter space shown in Fig. 1 from the present LEP2 data. We see that in all cases, already, the LEP2 data rule out a significant part of the $g_X - M_X$ plane for $S = 1$ but that the $S = 1$ leptoquark interpretation, like the $S = 0$ case, is still viable. According to the data from DESY, one should focus on the region below $M_X \cong 270$ GeV in Fig. 1. In this region, we see that the size of the excluded parameter space depends on the model, varying as it does, for spin 1 from a maximum of $\sim 34\%$ for model (2) down to a minimum of $\sim 11\%$ for model (3); for spin 0, the entire parameter space in Fig. 1 is allowed by present LEP2 data; in particular, all of the mass region suggested by the HERA data is allowed for $S = 0$ by the present LEP2 data. For $\delta \lesssim -0.5$, the entire mass region suggested by the DESY data is also still viable for $S = 1$. For $\delta = 0$, the value of M_X must be at least 220 GeV to be consistent with our LEP2 data constraint for spin 1.

The above results are consistent with those presented in Ref. [3] by Kamamiya for a scalar leptoquark when due account is taken of our strong isospin symmetry assumption

[1] In the process of combining experimental data from different LEP collaborations we have corrected data for slight difference in $(s'/s)_{\rm min}$.

[2] At $\sqrt{s} = 172.3$ GeV for $\sqrt{(s'/s)_{\rm min}} = 0.85$ we find from KORALZ $\sigma_{SM} = 28.43$pb and combined results of four LEP2 experiments [3] (all errors combined in quadrature) give us $(\sigma - \sigma_{SM})/\sigma_{SM} = 0.0472 \pm 0.037$.

and of our normalization of the respective leptoquark coupling constant. In Refs. [11,12], indirect bounds on leptoquarks were derived assuming only one such weak isospin particle multiplet with a given chirality of its quark coupling is present at a time. As we stated, in our work we do not assume weak isospin symmetry. If we want to use the results in Refs. [11, 12], we need to make some assumption about the leptoquark weak isospin mixing matrix in general. If we make the simplest possible assumption, that is that our states are composed of only those states in Refs. [11,12], then for spin 1 we may identify $\{T^{(-5/3)},(T^{(-2/3)}-S_L^{-(2/3)})/\sqrt{2}\} \Leftrightarrow \{X^{(-5/3)},X^{(-2/3)}\}$ in model (1), $\{\tilde{S}^{(-5/3)},S_R^{(-2/3)}\} \Leftrightarrow \{X^{(-5/3)},X^{(-2/3)}\}$ in model (2), $\{D_L^{(-4/3)},D_L^{(-1/3)}\} \Leftrightarrow \{X^{(-4/3)},X^{(-1/3)}\}$ in model (3), and $\{D_R^{(-4/3)},\tilde{D}^{(-1/3)}\} \Leftrightarrow \{X^{(-4/3)},X^{(-1/3)}\}$ in model (4); for spin 0, an analogous transformation would hold. These indentifications, with the attendant coupling constant relations $2g = g_X$, $\sqrt{2}g = g_X$, $\sqrt{2}g = g_X$, and $\sqrt{2}g = g_X$, respectively where g is the coupling constant in Refs. [11,12], lead to the bounds, from the formulas in Ref. [11,12], for spin 1, $M_X > (1+\delta)$ 1792 GeV, $M_X > (1+\delta)$ 956 GeV, $M_X > (1+\delta)$ 1895 GeV, and $M_X > (1+\delta)$ 956 GeV, respectively, for models (1-4); for spin 0, the corresponding results are $M_X > (1+\delta)$ 690 GeV, $M_X > (1+\delta)$ 1322 GeV, $M_X > (1+\delta)$ 675 GeV, and $M_X > (1+\delta)$ 1322 GeV, respectively. We see that even with this simple mixing assumption, the leptoquark interpretation is still viable for $\delta \lesssim -0.75$ (-0.55) for spin 1(0). This result is extremely dependent on the naive mixing assumption and on presuming only one model is present at a time. For example, if we have both model (1) and model (2) present for spin 1, our bounds in Fig. 1 would get stronger along the mass axis by a factor $\sim \sqrt{2}$ but the Leurer bounds we just derived would be obviated and replaced with much weaker bounds which follow from the formulas leading to Tables 3 and 4 in Ref. [11]; in our models, the formula leading to the Table 2 in Ref. [11] does not apply because we always have the relation $\eta_{S_L} = \eta_T$, in the notation of this last reference. We thus eagerly await more precise LEP2 data and more plentiful DESY data in order to proceed further with our consistency check between the two data sets. At this time, we see that the DESY phenomenon is not inconsistent with the current level of agreement between σ_{SM} and σ_{obs} for $e^+e^- \to hadrons$ at LEP2.

It is important to view the results presented in Fig. 1 and in the text above from the point of their relation to the data observed at HERA. Indeed, concerning the $S=1$ case, it has been noted in Ref. [6] that Tevatron data (see the Note Added below) require that the branching ratio $B(X \to e^{+}{}^{(}\bar{q}^{)}) \equiv B(e^{+}{}^{(}\bar{q}^{)})$ should be much less than 1 for $M_X \simeq 200$GeV unless the small signal has been missed for some reason [10]. We therefore need to comment on the interplay of our excluded region and the size of $B(e^{+}{}^{(}\bar{q}^{)})$ in relation to the actual size of the apparent signal at HERA. In a recent analysis, two of us (S.J. and B.F.L.W.) together with W. Placzek [15] have analyzed the HERA data using our YFS exponentiated MC event generator methods [16] as they are realized in the event generator LESKO-YFS [17–19]. In Ref. [15] it is shown that, for $\Gamma_X \simeq 2$GeV, the value of δ which reproduces the HERA signal best is $\sim -.72(-.68)$ for $S = 0(1)$ respectively, corresponding to the $B(e^+q) \cong 1.1\%(.9\%)$, thereby obviating the Tevatron $S=1$ bounds within the allowed regions presented above. For $B(e^+q) \cong 1$, the value of δ which reproduces the HERA signal best [15] is $\sim -.95$ for $S = 0,1$, corresponding to the expected much smaller coupling $g_X \sim .05 g_W$ in comparison to the optimal coupling in the small $B(e^+q)$, $\Gamma_X \cong 2$GeV case, where $g_X \cong .3 g_W$. The $S = 1$ unit e^+q branching ratio case, while still allowed by our results above, is, according to Ref. [6], already excluded by Tevatron data.

As a final point, we point-out that for $\delta = -0.9$ we do not observe sensitivity of our observable to the leptoquark effect, even for $M_X = 100$ GeV. Note that in this case the overall normalization of the leptoquark effect in the amplitudes is reduced by factor of 100; thus, such a loss of sensitivity should be expected. Indeed, for negative δ approaching -1 simple scaling of the mass limit is not to be expected. The effect of the X(leptoquark) amplitude becomes smaller in a non-linear way. It becomes more and more profound in respectively forward/backward directions. Effects of beam pipe cuts as well as effects on angular distributions then become essential in establishing data sensitivity in this case. The implied kind of the extended study is rather easy to perform as we have a full Monte Carlo at our disposal, but it is definitely beyond this quick note. It should be noted that, in many cases, e.g. [20, 21], it was shown that such angular effects improve significance substantially. We hope to participate in such studies as well elsewhere [22].

In summary, we have investigated the constraints placed by LEP2 data on the leptoquark interpretation of the anomalous positron-jet phenomenon at DESY. We used our KORALZ [13] Monte Carlo event generator so that higher order radiative corrections to the Born level leptoquark signal are calculated at the YFS exponentiated LL $\mathcal{O}(\alpha^2)$ $\bar{\beta}_0$ level, for both initial and final state radiation, in the framework of Ref. [23]. We find that, while a significant part of the spin 1 coupling-mass plane for the leptoquark is excluded, there still remains a large region of the plane that is viable for spin 1 and all of the respective parameter space considered is allowed for spin 0: $-1.0 \leq \delta \leq 0.0$, $150 GeV \leq M_X$. We look forward to more precise data which will address these remaining allowed regions.

Note Added: As we were writing this paper, we became aware of the work of J. Kalinowski *et al.* [7] in which the idea of a leptoquark interpretation of the DESY anomalous positron-jet events is analyzed for its implications in $e^+e^- \rightarrow hadrons$ at LEP2 energies; our work differs from theirs in that we actually work with the realistic YFS exponentiated LL $\mathcal{O}(\alpha^2)$ multiple photon radiatively corrected predictions of the respective effects at LEP2 and use them together with the available data to set exclusion limits of the would-be leptoquark like object whereas their work is at the Born level and gives generic expectations for the respective effects in $e^+e^- \rightarrow hadrons$. Where the two analyses overlap, they agree completely. We also recently became aware of the work of G. Altarelli *et al.* [6] and of J. Blumlein [10] in which the leptoquark interpretation is discussed with attention to the constraints following from TEVATRON data. The first of these latter works points-out that such data apparently already exclude the vector leptoquark with the mass ~ 200 GeV if it has either minimal vector or Yang-Mills type couplings to gluons and an appreciable BR to the e^+q, respectively $e^+\bar{q}$, final state; the second of these latter works argues that the implied signal, depending as it does in detail on cuts, BR's, etc., may very well be missed and hence that even under the stated assumptions the issue is still unsettled. If these assumptions are not valid, the vector leptoquark interpretation would then be unequivocally viable at this time. Finally, we recently became aware of an independent similar analysis by M. Doncheski and S. Godfrey [9] who reach conclusions similar to those we presented herein.

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