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TESTING THE VECTOR CONDENSATE MODEL OF ELECTROWEAK INTERACTIONS AT HIGH ENERGY e^+e^- COLLIDERS

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The vector condensate model is a version of the standard model where the symmetry is broken dynamically by introducing a doublet of vector fields leading to massive spin-one particles ($B^{\pm}$, B^0, $\overline{B^0}$) and preserving the main features of the standard model. The B-particles are heavy ($m_B \gtrsim 42.7$ GeV) and the model has a low momentum scale ($\lesssim 2.6$ TeV). In the present note we point out that B-particles are copiously produced in $e^+e^- \to B\overline{B}, B\overline{B}Z$ at LEP 200 and high energy e^+e^- colliders almost in the whole possible mass range.

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The vector condensate model [1, 2] replaces the scalar doublet in the standard model by a doublet of self-interacting vector fields ($B_\mu^{(+)}$, $B_\mu^{(0)}$) forming a nonvanishing condensate. This condensate breaks the gauge symmetry and generates vector boson and fermion masses, as well as it fixes the interactions. Gauge boson-weak current interactions are left untouched. The condensate is proportional to the Fermi coupling constant [1, 2], this leads to a low momentum scale of the model. Only pairs of B-particles can interact with other particles. $\overline{B}BV$ is the strongest interaction ($\approx \bar{f}_1 f_2 V$), $V = W, Z$. $VV\overline{B}B$ is weaker than VVH and approximately as strong as $HHVV$. Similarly, $\bar{f}fH$ is stronger than $\overline{B}B\bar{f}f$ and $(\overline{B}B)^2$ may be weak or strong depending on m_B. It has been shown that the model survives the test of the ρ parameter [2] and each momentum scale and m_{B^0} there is a range of m_{B^+}, where the model remains valid.

In what follows we would like to show that LEP 200 and possible high energy e^+e^- colliders of 500 GeV [3] and even higher energies (500–1500 GeV) provide excellent opportunities for studying B-bosons. At planned luminosities the yield of B's is large in $e^+e^- \to \overline{B}B$, $\overline{B}BZ$ up to near the maximum kinematically possible m_B's making the detection of B's realistic. In a recent work [1] the process $e^+e^- \to \overline{B}B$ was emphasized only for relatively small parameters, $m_B \lesssim 48$ GeV and $s^{1/2} \lesssim 100$ GeV.

For $\overline{B^0}B^0$ final states the relevant Lagrangian is

$$L = \frac{ig}{2\cos\theta_W}\partial^\mu B^{(0)\nu +}\left(Z_\mu B_\nu^{(0)} - Z_\nu B_\mu^{(0)}\right) + \text{h.c.}. \quad (1)$$

The cross section of the B^+B^- final state is 0.29 times that of $B^0\overline{B}^0$ at equal masses and energies. From (1) we get the cross section

$$\sigma(e^+e^- \to B^0\overline{B}^0) = g^4(s - 4m_{B^0}^2)^{3/2}(s + 3m_{B^0}^2)\left[1 + (4\sin^2\theta_W - 1)^2\right]$$
$$\times \left\{3072\pi\cos^4\theta_W m_{B^0}^2 s^{1/2}\left[\left(s - m_Z^2 + \frac{\Gamma_Z^2}{4}\right)^2 + m_Z^2\Gamma_Z^2\right]\right\}^{-1}. \quad (2)$$

Let us look at (2) beyond the Z resonance region. With increasing m_{B^0} after threshold the rise of the cross section is slower and at $s \gg m_{B^0}^2$ σ is proportional to $m_{B^0}^2$.

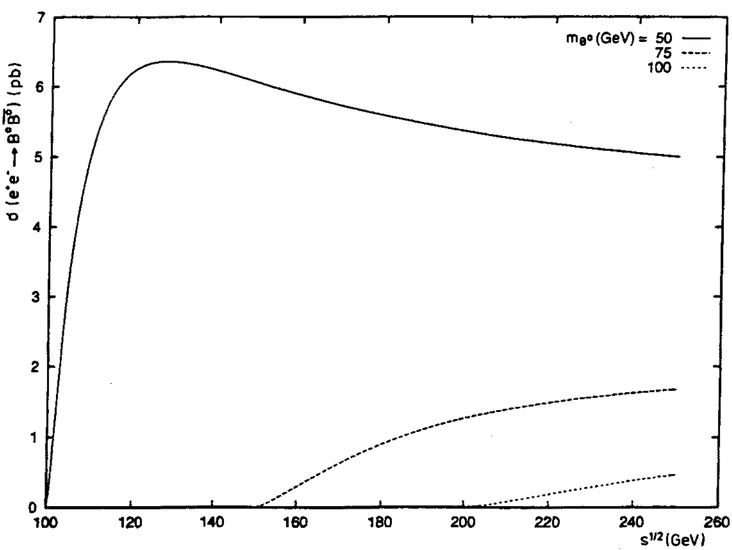

Fig. 1. The cross section of $e^+e^- \to B^0\overline{B^0}$ *vs.* $s^{1/2}$ at $m_{B^0} = 50, 75, 100$ GeV.

The cross section of the $B^0\overline{B}^0$ production is shown in Fig. 1 as the function of the total centre of mass energy $s^{1/2}$ at $m_{B^0} = 50, 75, 100$ GeV in the LEP 200 region. At an integrated luminosity of 500 pb^{-1}, for $m_{B^0} \lesssim 90$ GeV the yield of B's$\gtrsim 200$. The yield is quickly growing with decreasing m_{B^0}. The same process is worth studying at higher energies too. This is shown in Fig. 2, where $s^{1/2}$ runs in the energy range of the e^+e^- linear colliders of 500–1500 GeV and higher B masses are tested, $m_{B^0} = 100, 200, 300, 400, 500$ GeV. At the linear collider discussed in Ref. [3], $s^{1/2} = 500$ GeV ($m_{B^0} \leq 250$ GeV) and taking the popular luminosity of 10 fb^{-1} it follows that even a high B^0 mass results in a large number of events. For instance, for $m_{B^0} \lesssim 200$–240 GeV we get more than 800–200 events. At NLC (next linear collider) even higher masses can be searched for. At $s^{1/2} = 1.5$ TeV and 10 (100) fb^{-1} one gets more than 200 (1000) events for $m_{B^0} \lesssim 500$ (700) GeV, and the yield is growing with decreasing m_{B^0}.

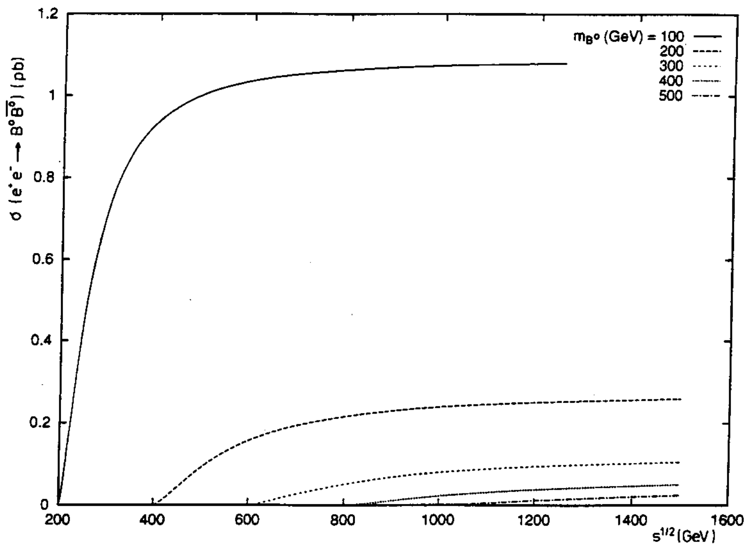

Fig. 2. The same as Fig. 1 at $m_{B^0} = 100, 200, 300, 400, 500$ GeV.

Another process providing a rather large yield of B's is $e^+e^- \to Z^* \to B^0\overline{B}^0 Z$ analogous to the Higgs production $e^+e^- \to ZH$. The relevant Lagrangian is

$$L = \frac{g^2}{4\cos^2\theta_W}\Big(- Z_\mu Z^\mu B^{(0)+}_\nu B^{(0)\nu} + Z_\nu Z^\mu B^{(0)+}_\mu B^{(0)\nu}\Big) . \qquad (3)$$

Its total cross section has been calculated by computer and the result is shown in Fig. 3. At (500 GeV, 10 fb^{-1}) higher m_{B^0} than 50 GeV cannot be discovered. At 1.5 TeV the yield is greater than 200 (100) for $m_{B^0} \lesssim 300$ (500)

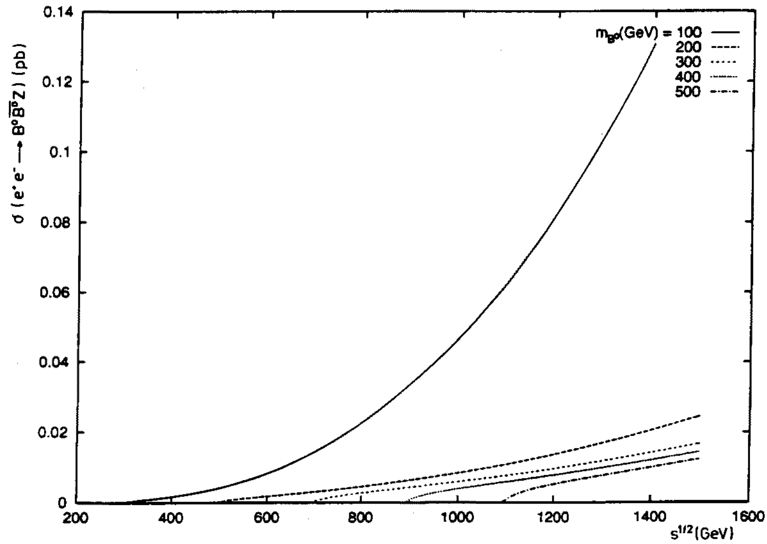

Fig. 3. The cross section of $e^+e^- \to B^0\overline{B^0}Z$ *vs.* $s^{1/2}$ at $m_{B^0} = 100, 200, 300, 400,$ 500 GeV.

GeV. At a higher luminosity of 100 fb^{-1}, however, $m_{B^0} \lesssim 650$ GeV provides more than 300 events and the kinematical limit is almost accessible.

In conclusion, we have shown that the heavy spin-one B-particles originating from the vector condensate model of electroweak symmetry breaking could be seen at high energy e^+e^- colliders up to masses of several hundred GeV.

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