Sensitivity to New Physics in Parity Violating Asymmetries at RHIC

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We have presented the sensitivity of the RHIC Spin experiment to some new physics contributions, from the analysis of the Parity Violating (PV) asymmetry $A_{LL}^{PV}(\equiv d\sigma^{--} - d\sigma^{++}/d\sigma^{--} + d\sigma^{++})$ defined for jet production ($d\sigma \equiv d\sigma_{1-jet}$).

In the first part, we have recalled the sensitivity to the presence of some new quark-quark Contact Interactions (CI). Such CI could represent some effects of quark compositeness. At RHIC, with the conventional parameters of the experiment, we will be sensitive to some energy scales of $\Lambda \sim 3-4\,TeV$, if PV is maximal. It appears that the RHIC is perfectly competitive with the TEVATRON for the discovery of CI, however, we have to note that the integrated luminosity is a key parameter for the polarized analysis. The study of A_{LL}^{PV} could give some unique informations on the chiral structure of the new interaction.

The second part was devoted to a review of the different theoretical motivations for the presence of a "leptphobic" Z' of relatively low mass, that we briefly report now : 1) Leptophobia corresponds to some new interactions belonging to the "pure" quark sector. 2) Leptophobic Z' appears naturally in several models derived from string theory. Within these models, the absence of Z' leptonic couplings appears in several ways : from the classification of the fermions in the different representations of the gauge group, or from kinetic mixing between two abelian gauge groups which produces a mixing between the charges of the fermions under these two U(1) factors. 3) Some theoretically consistant leptophobic Z' bosons have been constructed also for non-supersymmetric models. 4) In the framework of supersymmetric models with an additional abelian gauge factor $U(1)'$, it has been shown that the Z' boson could appear with a relatively low mass ($M_Z \leq M_{Z'} \leq 1\,TeV$) and with a mixing angle with the Z close to zero. In addition, these classes of models have several appealing features for soft supersymmetry breaking and for cosmology. 4) The present experimental constraints on these models are rather weak. Several classes of models are absolutely unconstraint. 5) All these theoretically motivated models exhibit, in general, some PV couplings to up and down quarks, which could induce some interesting effects on A_{LL}^{PV} measured in $p-p$ or/and $n-n$ collisions at RHIC. The main results are presented in the following transparencies.

The last section concerned the measurement of A_{LL}^{PV} in $p-n$ collisions, which could detect the presence of a new charged boson W' unconstraint by present experimental data.

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3°) Properties for up / A_{LL}^{PV} in p-p collisions

In general, the leptophobic Z' violates Parity in the up quark sector !

- "Flipped SU(5)" : Maximal PV !

$$C_L^{u'} = \pm 1/2 \qquad C_R^{u'} = 0 \qquad (\Rightarrow \text{Left})$$

- "g-kinetic" : $C_R^{u'} = -2\, C_L^{u'} = 1/3$ $\quad (\Rightarrow \text{Right})$

- The constraint of <u>all</u> the "classes" of models is:

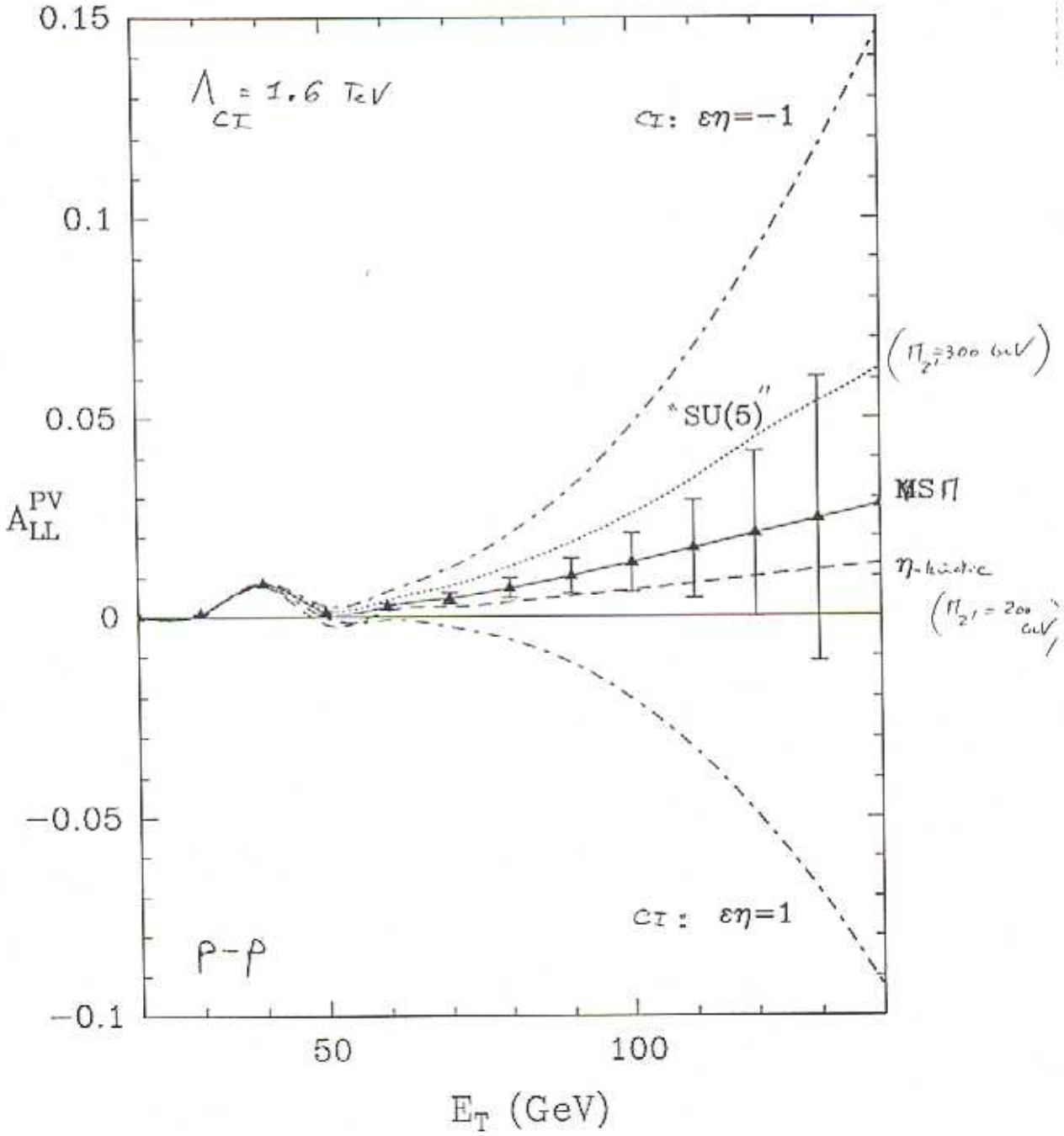
$$C_L^{u'} \neq C_R^{u'}$$

ie: axial couplings $(C_L^{u'} = -C_R^{u'})$ authorized $\Rightarrow$ No effect on A_{LL}^{PV} !

Except this case, for $M_{Z'} \lesssim 300 - 400$ GeV, these models could be detected at RHIC from A_{LL}^{PV} in p-p collisions !

error bars: $\sqrt{s} = 500$ GeV
$L = 800\ pb^{-1}$
$\Delta E_T = 10$ GeV
$\Delta y = 1$

$$\frac{\Delta A_{systematic}}{A} = 10\%$$



3°] Properties for down / A_{LL}^{PV} in n-n collisions

Isospin symmetry $\Longrightarrow$ $A_{LL}^{PV}(n\text{-}n)$ tests d

What could we expect from these Z'?

$\rightarrow$ Models with Parity Conservation (for d)

($\Rightarrow$ No effect on $A_{LL}^{PV}(n\text{-}n)$)

- "flipped SU(5)" and "η-kinetic" are PC : $C_L^d = \pm C_R^d$
- PC for d is a general property of the <u>minimal</u> 2 doublets Higgs model

$$h_u \, Q \, u^c \, H_u + h_d \, Q \, d^c \, H_d + h_e \, L \, e^c \, H_d \in \mathcal{L}_Y / W$$

⚠ $Q'(f)$: charge of f under $U(1)'$
$C_L^{f\,\prime} = Q'(f)$
$C_R^{f\,\prime} = -Q'(f^c)$

Leptophobia $\equiv$ $Q'(L) = 0 = Q'(e^c)$

$\Rightarrow Q'(H_d) = 0 \quad \Rightarrow \quad Q'(Q) + Q'(d^c) = 0$

$\Longrightarrow \quad C_L^{d\,\prime} = C_R^{d\,\prime}$ i.e. Vectorial couplings

→ Non-Minimal Higgs Models

- 3 Higgs doublets (Georgi - Glashow) Agashe et al.

- 2 Higgs doublets + d mass terms (in W) from higher dimensional operators: (Cvetič et al)

  Natural in string models (Faraggi PLB377 (96) 43)

They do <u>not</u> impose PC for d, conversely we often have: $C_L'^d \neq C_R^{d'}$

(i.e. PV for d except for the axial case)

- Interesting model: "Mirror Z" (Caravaglio & Ross PLB 346 (95) 159)

$$\frac{C_L^q}{C_R^q} = \frac{C_R^{q'}}{C_L^{q'}} \quad \Rightarrow \quad \begin{cases} C_R^{u'} \simeq -2\, C_L^{u'} \\ C_R^{d'} \simeq -5\, C_L^{d'} \end{cases}$$

We expect strong PV for d in this model!

(No curves for $A_{LL}^{PV}(n,n)$, Sorry! Available soon.)

Conclusions: • $A_{LL}^{PV}(n,n)$ is sensitive to NP if PV/a

• It could constraint the <u>scalar sector</u> of the new theory!

4°) Experimental Constraints

- Direct:

Come from σ_{jet}^{unpol}

UA2 : forbids for $K = \frac{g_{Z'}}{g_Z} = 1$: $100 < M_{Z'} < 250$ GeV

DØ : " " $365 < M_{Z'} < 615$

CDF : no-constraints

→ limits obtained for SM-like Z' (i.e. same coupling

→ limits highly model dependent

→ Disappear for $K \lesssim 0.95$ — need $K \lesssim 0.9$ for DØ high masses. Domain irrelevant for RHIC;

(Re : $K_{GUT} \sim 0.7$!)

"g-kinetic" absolutely unconstrained (and far to be

→ Large uncertainties (exp. + th.) for σ_{jet}^{unpol} !

- Indirect

From Z-pole (LEP/SLC) + low energy PV ⟶ $\theta_{Z-Z'} \lesssim 10^{-2}$, 10^{-3}

In leptophobic Z' models, in general, $\theta_{Z-Z'}$ is naturally ~ 0

- conclusion:

Low mass leptophobic Z' are not in contradiction with present experiments!

III W′ at RHIC

(P. Taxil & SMV PL B404 (97) 302)

A_{LL}^{PV} is sensitive to a W′ in p–n collisions

(result from Isospin symmetry)

→: SM effects: pp: Z-g ~ 70 % W-g ~ 30 %

pn: Z-g ~ 2 % W-g ~ 98 % !!

→ W_R from LRM

Limits on M_{W_R} are highly model dependant

Relevant parameters: (Langacker & Uma Sankar PRD40 (89))

V_{CKM}^R, ν_R $K = \frac{g_R}{g_L}$, ξ, ω (CP phases) $\theta_{W_L - W_R}$

Case the weakest constraint: $V_{CKM}^R \sim \mathbb{1}$, ν_R heavy Dirac

(natural! less (!))

A_{LL}^{PV} in p–n collisions is sensitive

to this model if $M_{W_R'} \lesssim 400$ GeV

($K \simeq 0.9$)