On the free field realization of $WBC_n$ algebras

Z. Bajnok

Institute for Theoretical Physics
Roland Eötvös University,
H-1088 Budapest, Puskin u. 5-7, Hungary

February 26, 1997

Abstract

Defining the $WBC_n$ algebras as the commutant of certain screening charges a special form for the classical generators is obtained which does not change under quantisation. This enables us to give explicitly the first few generators in a compact form for arbitrary $WBC_n$ algebras.
1 Introduction

The first definition of the $W$-algebras was given by Fateev and Lukyanov in [1]. They defined the classical $W$-algebras using the Miura transformation, consequently the algebras were presented in their free field form. In order to find the quantum analogue they quantised the free fields and normal ordered the classical expressions. Then the screening charges, operators that commute with the $W$-generators, were identified since both the screening operators and the $W$-generators are necessary in the investigation of the representation theory. Unfortunately this quantisation procedure works only for the $A_n$ and $D_n$ series, but fails to work for $C_n$ and $B_n$. To avoid this problem they modified the screening operators and the $W$-generators simultaneously for the $B_n$ algebras but in doing so the correspondence to the classical theory is lost.

Using an alternative definition of the quantum $W$-algebras Feigin and Frenkel realized [2], that most naturally one can define the $W$-generators and so the algebras as the commutant of the screening charges. They also computed the classical counterpart and showed the relation between them: they first proved the existence of the classical generators then proved their survival at the quantum level.

Although the existence of the quantum generators is established their explicit form is still unknown in the general case. In fact, Lukyanov and Fateev’s quantum expressions for $A_n$ and $D_n$ still work, since in this case the polynomial form of the $W$-generators does not change only the coefficients get quantum corrections. The aim of this paper is to find similar expressions for the missing $B_n$ and $C_n$ cases, i.e. to find such a form for the generators at the classical level, which in this sense survive quantisation. Since there are applications where the $W$-generators are explicitly needed [10, 13] we also give explicit expressions, in a very compact form, for the first few generators of arbitrary $WBC_n$ algebras. (See also [11] for related results).

The paper is organised as follows: in Section 2 we review the earlier results concerning the definition and quantisation of $W$-algebras. Then in Section 3 we consider the classical theory and find a form for the generators which turns out to be very useful at the quantum level. In Section 4 we prove that the classical form does not change and give explicit results. Afterwards we conclude in Section 5.

2 $WG$ algebras as commutant of screening operators

Usually the $WG$ algebras are defined as the reduction of the Kac-Moody (KM) algebras corresponding to the principal $sl_2$ embeddings [8]. On can show that this is equivalent to look only for the Cartan currents of the KM algebra in question and find the commutant of certain screening charges [3].

In more detail one defines the $WG$ algebra as a vertex operator sub-algebra of the KM algebra’s Cartan sub-algebra. The commutation relations of the modes of the ghost-modified Cartan currents [3, 5] are encoded in

$$\hat{J}^i_1|\hat{J}^j_{-1}\rangle = \alpha_{ij}(k + h)|0\rangle = \alpha_{ij}\kappa|0\rangle,$$

where $k$ denotes the level and $h$ the dual Coxeter number. The $\hat{J}^i$ correspond to the simple roots, $\alpha_i$, and $\alpha_{ij} = \alpha_i \cdot \alpha_j$ is the inner product matrix of $G$. The space of states is spanned by
the negative modes of the currents and the WG algebra is nothing but the only non-vanishing cohomology of the BRST charge $\sum_i Q_i$, consisting of the sum of the screening charges, $Q_i$,

$$Q_i = \sum_{n \leq 0} S^i_{n+1}(\tilde{J}^i_-) S^i_n(\tilde{J}^i_+) \quad ; \quad \sum_{n \leq 0} S^i_n(x^i_+ z^n = \prod_{m < 0} e^{\pm \frac{im}{m} z^m}. \quad (2)$$

The kernel of $Q_i$ coincides with the kernel of $\oint \frac{dz}{2\pi i} : e^{\oint z^i (w) dw} ..$. The classical limit can be associated to $\kappa \to 0 [3]$. In this case the classical screening charges become:

$$\tilde{Q}_i = -\kappa^{-1} \lim_{\kappa \to 0} Q_i = \sum_{n<0, j} S^i_{n+1}(\tilde{J}^i_-) \alpha_{ij} \frac{\partial}{\partial J^i_h} = \sum_{n<0} S^i_{n+1}(\sum_j \alpha_{ij} h^j_{-}) \partial^n_{h_j} \quad ; \quad \partial^n_{h_j} = \frac{\partial}{\partial h^n_{-j}}, \quad (3)$$

where we have introduced the $\sum_i \alpha_{ij} h^j_{-} = \tilde{J}^i_-$ variables, which correspond to the fundamental co-weights. Here, analogously to the quantum case, $h^i_{m-1}$ represents the $(m!)^{-1} \partial^m h^i(z)$ classical field. The classical analogue of $L_{-1}$ is $\partial = \sum_{m<0} \sum_{i=1}^{dim} mh^i_{m-1} \partial^m_i$, which is the operator of the differentiation on the differential polynomials of the classical fields, $h^i(z)$.

Using the fact that $\tilde{Q}_i$-s satisfy the Serre relation of the algebra Feigin and Frenkel proved that the kernel of these operators is spanned by elements $W_{e_{i+1}}$ of degree $e_i + 1$ together with products of their derivatives. Here the $e_i$-s denote the exponents of the Lie algebra. Modifying the proof slightly one can show that taking a subset $I \subset \{1, \ldots, n\}$, the common kernel of the $\tilde{Q}_i$ operators for $i \in I$ consists of the $W$-generators of the associated sub-algebra, (whose simple roots are $\alpha_i$, $i \in I$), and the remaining $h^j$, $j \notin I$ variables. As a consequence the kernel of $Q_i$ is generated by $L^{(i)}$ and $h^j_n$, $j \neq i$, where $L^{(i)}$ is defined as

$$\partial^2 + (h_{i+1} - h_{i-1}) \partial + L^{(i)} = (\partial + h_{i+1} - h_i)(\partial + h_i - h_{i-1}), \quad (4)$$

(if $\alpha_{ij} = 2\delta_{ij} - \delta_{i-1,j} - \delta_{i+1,j}$). Here and from now on we abbreviate $h^i_{-1}$ by $h_i$. The translation covariance of this expression motivates one to find the $A_n$ generators in the following form:

$$(\partial - h_n) \ldots (\partial + h_{i+1} - h_i)(\partial + h_i - h_{i-1}) \ldots (\partial + h_1) = \sum_{i=0}^n W_i^A \partial^{n-i}. \quad (5)$$

Unfortunately this translation covariance is absent in the the $C_n$ and $B_n$ case, for this reason we choose the following strategy. As a starting point we consider the first $n-1$ screening operators. Since they are exactly the same as in the $A_n$ case one knows their kernel and the corresponding generators. In order to find the common kernel we need $L^{(n)} = h_n h_n - 2h_n h_{n-1} - \partial h_n$ so we combine (3) with its adjoint and obtain the correct answer:

$$(\partial - h_1) \ldots (\partial + h_{n-1} - 2h_n)(\partial + h_n - h_{n-1}) \ldots (\partial + h_1) = \sum_i W_i^{C_n} \partial^{2(n-i)} + \text{odd terms}. \quad (6)$$

One has a similar solution for $B_n$:

$$(\partial - h_1) \ldots (\partial + h_{n-1} - h_n)\partial(\partial + h_n - h_{n-1}) \ldots (\partial + h_1) = \sum_i W_i^{B_n} \partial^{2(n-i)+1} + \text{even terms}. \quad (7)$$
The quantum case is much more involved. Since the quantum operators satisfy the q-Serre relations of the underlying q-deformed Lie algebra the classical $W$-generators survive [3]. However this means that the commutant of the subset of the $Q_i$ operators, in harmony with the classical theory, consists of the $W$-generators of the associated sub-algebra and the remaining $h^j$, $j \neq i$ variables. To find the explicit quantum expressions one tries the classical form modified according to expressions one tries the classical form modified according to:

\[
\sum_{i=0}^{n} S_{2i}^{W} \partial^{2(n-i)} + \text{odd terms} = \left( \partial^n - \partial^{n-1}W_1 + \ldots + (-1)^nW_n \right) \left( W_n + \ldots + W_1 \partial^{-1} + \partial^n \right).
\]  

(11)

In order for $(\partial+2h_n-h_{n-1})$ to be the same as in the $A_n$ case: $(\partial+h_n-h_{n-1})$, we rescaled $h_n$ by a factor two. Here the $W_k$’s span the kernel of the $Q_1, \ldots, Q_{n-1}$ operators. Clearly $W_1 = h_n$. Moreover if one takes the $h_1 \to 0$ limit then $W_n \to 0$ and for all the others we recover the generators related to the $A_{n-1}$ algebra.

Unfortunately in the definition above the $W_{2i}^{W}$ generators explicitly depend on $n$. We would like to redefine them $n$-independently. We also need a form for the $W_{2k}^{W}$ generator such that $W_{2k}^{W} \to 0$ when $W_l \to 0$, $l = n, n-1, \ldots k$. This can be achieved by the following way: define the generators by:

\[
(\partial^n - \partial^{n-1}W_1 + \ldots + (-1)^nW_n) (W_n + \ldots + W_1 \partial^{-1} + \partial^n) = \\
\partial^n \partial^n + \partial^{n-1}W_2^{Cn} \partial^{-1} + \partial^{n-2}W_4^{Cn} \partial^{-2} + \ldots + \partial^{n-k}W_{2k}^{Cn} \partial^{-k} + \ldots + W_{2n}^{Cn}.
\]  

(12)
It is not completely clear at first that this definition is correct. Writing this expression into the original form \((6)\), one can see that at each even level \((12)\) really defines the generator, however at odd levels it is a nontrivial statement. In order to prove it first we note that
\[
W_{2n}^{C_n} = \left( \partial^n - \partial^{n-1}W_1 + \ldots + (-1)^nW_n \right) W_n. \tag{13}
\]
This shows that if we take the \(h_1 \to 0\) limit then \(W_{2n}^{C_n} \to 0\) while for all the other generators we have \(W_{2k}^{C_n} \to W_{2k-1}^{C_n}\). This indicates that the \(W_{2k}^{C_n}\) generators share the property needed above, i.e. \(W_{2k}^{C_n} \to 0\) when \(W_l \to 0\), \(l = n, \ldots, k\). It is also clear that the generators are \(n\)-independent. Now the terms at odd level have to be in the kernel of all the screening charges. This means that they have to be a linear combination of the derivatives of the \(W_{2k}^{C_n}\) generators defined at even levels. However one can determine the coefficients of this combination from the \(W_k W_k\) term of \(W_{2k}^{C_n}\), which are exactly what is needed.

Summarizing the classical generator has the following form:
\[
W_{2k}^{C_n} = \sum_{i,j,l,m} c_{ij}^{lm} \partial^i W_l \partial^j W_m, \tag{14}
\]
where \(i + j + l + m = 2k\) and \(l \leq k \leq m\).

Here we list the first few generators since we will need their explicit form at the quantum level.
\[
\begin{align*}
W_2^{C_n} &= 2W_2 - (W_1)^2 + \partial W_1 \\
W_4^{C_n} &= 2W_4 + 3\partial W_3 - 2W_1 W_3 + W_2 W_2 - (\partial W_1) W_2 - W_1 \partial W_2 + \partial^2 W_2 \\
W_6^{C_n} &= 2W_6 - 2W_1 W_5 + 2W_2 W_4 - W_3 W_3 + 5\partial W_5 - 3\partial (W_1 W_4) \\
&\quad + \partial (W_2 W_3) + 4\partial^2 W_4 - \partial^2 (W_1 W_3) + \partial^3 W_3.
\end{align*} \tag{15}
\]

Similar considerations can be done also for the \(B_n\) algebras.

## 4 Quantum considerations

First we will show that the quantum generator has the same polynomial form as the classical one \((14)\) only the \(c_{ij}^{lm}\) coefficients get quantum corrections:
\[
W_{2k}^{C_n} = \sum_{i,j,l,m} c_{ij}^{lm(\kappa)} \partial^i W_l \partial^j W_m, \tag{16}
\]
where now \(W_l\) denotes the explicitly known quantised \(A_n\)-type expression, \((9,12)\) and normal ordering has to be understood.

The idea of the proof is to show that terms containing more than two \(h_n\)-s can be removed systematically since they are absent at the classical level, \((6)\). As a starting point we write down the most general expression which commute with the first \((n-1)\) screening operators:
\[
W_{2k}^{C_n} = \sum_{j_1,\ldots,j_l, i_1,\ldots,i_l} c_{j_1,\ldots,j_l, i_1,\ldots,i_l(\kappa)} \partial^{j_1} W_{j_1} \ldots \partial^{i_l} W_{i_l}. \tag{17}
\]
Now we demand for it to be in the kernel of \( Q_n \) i.e. to contain \( L^{(n)} = h_n h_n - 2h_n h_{n-1} - (1 - 2\kappa) \partial h_n \):

\[
W_{2k}^{C_n} = \sum_{i_1, \ldots, i_1} b^{i_1, \ldots, i_1}(\kappa) \partial^{i_1} L^{(n)} \ldots \partial^{i_1} L^{(n)} \{ \text{terms without } h_n \}.
\]  

(18)

We have to redefine this \( W \)-generator such that the new one contains the products of at most two \( W \)-s. We will do it inductively: we define a partial ordering on the space of states. We say that \( \partial^{i_1} h_n \ldots \partial^{k} h_n \partial^{k+1} h_{i_1} \ldots \partial^{k+s} h_{i_s} \) is bigger than \( \partial^{j_1} h_n \ldots \partial^{m} h_n \partial^{m+1} h_{j_1} \ldots \partial^{m+s} h_{j_s} \) if \( k > m \) or if \( k = m \) then if \( s > t \). This induces an ordering among the \( c \) coefficients if we associate the \( h_n h_{n-1} \ldots \partial^h_{n-j+1} \) highest grade term to \( \partial^h_j \). (We note that the restriction of this map to the highest grade is injective, moreover normal ordering and other quantum corrections contribute at lower grades only). Now consider the highest grade terms in the expressions, (17–18), together with their \( W_i \) and \( L^{(n)} \) generators. We show in the Appendix that there exist a classical \( W \)-generator with these highest grade terms. This means however that the unneeded highest grade terms can be removed by redefining the \( W \)-generator, (17). Doing this procedure from grade to grade we end up with the original form (13).

In order to compute the coefficients explicitly we will use duality [7]. It states that if one replaces \( h_i \) by \( \beta h_i \), where \( \beta^2 = \kappa \) and defines \( \tilde{W}_{2k}^{C_n}(\beta) = \beta^{-2k} W_{2k}^{C_n}(\beta h_i) \), (and similarly for \( B_n \)) then

\[
\tilde{W}_{2k}^{C_n}(\beta) = \tilde{W}_{2k}^{B_n}(\beta^{-1}.
\]  

(19)

Since the \( A_n \) algebra is self-dual this transformation acts only on the \( c \) coefficients in the expression (19). In more detail this means that rescaling the generators into their original forms the coefficient of the \( k^{i+j} \) term in \( c_{ij}^{(k)}(\kappa) \) for the \( C_n \) algebra becomes the coefficient of the \( (-\kappa)^m \) term in the analogous expression for \( B_n \).

The duality transformation makes it possible to give the quantum generator at level two:

\[
W_2^{C_n} = 2W_2 - (W_1)^2 + (1 - 2\kappa) \partial W_1.
\]  

(20)

This form of the generator is \( n \)-independent and thus it is the same for all the \( WBC_n \) algebras.

Let’s consider the next case, at level four:

\[
W_4^{C_n} = aW_4 + b\partial W_3 + cW_1 W_3 + W_2 W_2 + d\partial W_1 W_2 + eW_1 \partial W_2 + f \partial^2 W_2, 
\]  

(21)

where the terms without quantum corrections are: \( a = 2 \) and \( c = -2 \). Duality restricts the others as

\[
b = 3 - 4\kappa \quad ; \quad d = -1 \quad ; \quad e = -(1 - 2\kappa) \quad ; \quad f = 1 + f_1 \kappa + 2\kappa^2 ,
\]  

(22)

where the \( f_1 \) term is still unknown. However this is not surprising since it may depend on the choice of the normal ordering of the \( W_2 W_2 \) term, (all the other normal orderings are trivial in (21)). We note that the \( W_k \) generators are exactly the same for the \( A_n \), \( B_n \) and \( C_n \) algebras since the first \( (n - 1) \) screening charges coincide. This means that computing the normal ordering one can use any of these possibilities, moreover the normal ordering corresponding to the \( N > n \) algebras. These choices are different since the normal ordering uses the inverse of the inner product matrix. The difference of the different orderings has to be in the kernel of the first \( (n - 1) \) generators so it can be expressed in terms of the \( W_i \)-s, moreover it contains at most
two $h_n$-s, so it has the form (16). Note that the induced terms and so the quantised generator $W_4^{C_n}$ may contain the classically removed $W_1$-s. However taking the $W_k \to 0$, $k = 2, 3, 4$ limit the generator $W_4^{C_1}$ obtained has to be proportional to $\partial^2 W_2^{C_1}$, so we can take such a linear combination of the generators $W_4^{C_n}$ and $\partial^2 W_2^{C_n}$ which does not contain the $W_1$ operator. We chose a normal ordering which is exceptional in the sense that it contains the fewest new terms:

$$ : W_2 W_2 : = (W_2 W_2)|C_n + \frac{\kappa}{2} \partial^2 W_2 - \ldots, \quad (23) $$

where the dots mean that we removed the induced $n$-dependent $W_1$ terms and the subscript $C_n$ means that we used the inner product matrix of the $C_n$ algebra. Now the term $f$ becomes $(1 - \kappa)(1 - 2\kappa)$ and thus $f_1 = -3\kappa$.

Next consider the generator at level six. The terms which contain at most one derivatives are determined by duality:

$$
2W_6 - 2W_1 W_5 + 2W_2 W_4 - W_3 W_3 + \partial(W_2)W_3 + (5 - 6\kappa)\partial W_5 \\
-(3 - 4\kappa)\partial(W_1)W_4 - (3 - 2\kappa)W_1\partial W_4 + (1 - 2\kappa)W_2\partial W_3. \quad (24)
$$

The other terms we compute in the $C_3$ model. Doing explicitly the calculations we have:

$$
-(1 - \kappa)(1 - 2\kappa)W_1 \partial^2 W_3 - (2 - \kappa)(1 - 2\kappa)\partial W_1 \partial W_3 \\
-2(1 - \kappa)(\partial^3 W_1)W_3 + (1 - \kappa)^2(1 - 2\kappa)\partial^3 W_3. \quad (25)
$$

If one computes the same terms in the $C_n$ case the coefficients may change due to the normal ordering which depends on $n$. The best one can do is to define an $n$-independent normal ordering. However to do it in the general case one has to know the various defining relations of the $W$-algebras which is still missing. Concretely in the $C_3$ case there are induced lower level terms:

$$
\frac{\kappa}{12}(8\kappa - 7)\partial^3 W_3 - \frac{\kappa}{2}\partial W_2 \partial W_2 - \frac{\kappa}{12}(10\kappa - 7)W_1 \partial^3 W_2 \\
+ \frac{\kappa}{2}(3 - 4\kappa)\partial W_1 \partial^2 W_2 + \frac{\kappa}{2}(2\kappa + 1)\partial^2 W_1 \partial W_2 + \frac{\kappa}{2}(12\kappa - 7)\partial^3 W_1 W_2. \quad (26)
$$

The generator at level six is the sum of (24), (23) and (26).

## 5 Conclusion

We analyzed the generators of the $WBC_n$ algebra using the explicitly know generators of the $WA_n$ algebra. Starting at the classical level we found a special $n$-independent form which does not change under quantisation. In the general case to make it more explicit and go beyond the terms determined by duality one has to compute the normal ordering explicitly for all the $W$-generators.

### Acknowledgements

We would like to thank L. Palla and L. Fehér for the critical reading and the helpful comments. This work was supported by OTKA T016251 and OTKA F019477.
6 Appendix

The proof is very technical so we just sketch it. First we introduce the notations: In terms of the classical fields, \( u_i = h_i - h_{i-1} \) (with \( h_0 = 0 \)), the sum of the leading terms of the generator \( W_k \), which is denoted by \( w_k \), become the \( k \)-th elementary symmetric polynomial:

\[
w_k = \sum_{i_1 < \ldots < i_k} u_{i_1} \ldots u_{i_k}
\]

(27)

If \( A_x \) denotes the algebra of the differential polynomials of the arbitrary classical field \( x \) and we abbreviate \( A_{w_1,\ldots,w_n} \) by \( A_w \), then the statement we have to prove is the following, (see (17,18)),

\[
A_w \cap A_{u^2_1} = A_{w^2_1,\ldots,w^2_n} = A_{w^c}
\]

(28)

where \( w^c_{2k} \) denotes the sum of the leading terms of the classical generator \( W^C_{2k} \), i.e. \( w^c_i = w^2_1 - 2w_2, \ldots, w^2_{2n} = (-1)^n w_n w_n \).

Clearly the algebra \( A_w \) is a subalgebra of \( A_{sym} \), the algebra of the symmetric differential polynomials in the fields \( u_i \)-s for which a polynomial basis is given by

\[
p_{n_1,\ldots,n_k} = \sum_{i_1,\ldots,i_k; all \neq} \partial^{n_1} u_{i_1} \ldots \partial^{n_k} u_{i_k}, \ n_i \leq n_{i+1}; \ k = 1, 2, \ldots, n
\]

(29)

see [2] for the details. Consequently

\[
A_w \cap A_{u^2_1} = A_w \cap A_{sym^2},
\]

(30)

where \( A_{sym^2} \) denotes the algebra of the symmetric differential polynomials in the fields \( u^2_i \)-s, with polynomial basis \( p_{n_1,\ldots,n_k} = p_{n_1,\ldots,n_k}(u_i \rightarrow u^2_i) \). Note that \( P_{n_1,\ldots,n_k} = w^c_{2k} \) if \( n_i = 0 \) for all \( i \).

Define the endomorphism \( \varphi \) on \( A_{sym} \) by

\[
\varphi(p_{n_1,\ldots,n_k}) = \begin{cases} 
p_{n_1,\ldots,n_k} & \text{if } n_1 = n_2 = \ldots = n_{k-1} = 0 \\
0 & \text{otherwise}
\end{cases}
\]

(31)

It is not hard to see that \( \varphi : A_w \rightarrow A_{sym}/\text{Ker} \varphi \) is an isomorphism.

Note also that \( P_{n_1,\ldots,n_k} = \sum_{i_1,\ldots,i_k; all \neq} \partial^{n_1} u^2_{i_1} \ldots \partial^{n_k} u^2_{i_k} \) is a linear combination of terms of the form \( p_{i_1,\ldots,i_k} p_{i_{k+1},\ldots,i_{2k}} \), where \( i_1, \ldots, i_{2k} \) is any of the permutations of the non-negative integers \( j_1, \ldots, j_k, n_1 - j_1, \ldots, n_k - j_k \). This shows that \( P_{n_1,\ldots,n_k} \in \text{Ker} \varphi \) except if \( n_1 = n_2 = \ldots = n_{k-1} = 0 \). Since \( P_{0,0,\ldots,0,n_k} = \partial^{n_k} P_{0,0,\ldots,0} \) on \( A_{sym}/\text{Ker} \varphi \), which is isomorphic to \( A_w \), and \( P_{0,0,\ldots,0} = w^c_{2k} \) the statement is proved.

References

[1] V. A. Fateev, S. L. Lukyanov, Sov. Sci. Rev. A. Phys. Vol. 15 (1990) 1-117.
[2] B. Feigin, E. Frenkel, Proceedings C.I.M.E. 93, Montecatini, June 1993.
[3] B. Feigin, E. Frenkel, Phys. Lett. 246B (1990) 75.
[4] J. de Boer and T. Tjin, Commun. Math. Phys. 158 (1993) 485.

[5] M.R. Niedermaier, MPI-Ph/93-91, hep-th:9402058.

[6] H.G.Kausch, G.M.T. Watts, Int. J. Mod. Phys. A7 (1992) 4175.

[7] H.G.Kausch, G.M.T.Watts, Nucl. Phys. B386 (1992) 166.

[8] J. Balog, L. Fehér, P. Forgács, L. O’Raifeartaigh, A. Wipf, Ann. of Phys. 203 (1990) 76.

[9] P. Bouwknegt, K. Schoutens, Physics Reports 223 (1993) 183.

[10] P. Furlan, A. Ch. Ganchev, V. B. Petkova, Nucl. Phys. B431 (1994) 622.

[11] K. Ito, S. Terashima, Phys. Lett. 354B (1995) 220.

[12] H. Weyl, The classical groups, Princeton Mathematical Series, p. 37.

[13] Z. Bajnok, Int. J. Mod. Phys. A9 (1994) 5387.