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Wigner Operators of Angular Momentum in Phase Space

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Abstract

We define two kind of Wigner angular momentum operators, which are the sum and the difference of the ordinary angular momentum operators $\vec{L}$ and $\vec{L}^*$ in the Weyl representation. These operators are as follows

$$\vec{W}^+ = 2(\vec{q}\times\vec{p}) + \frac{\hbar^2}{2}\vec{\nabla}_p\times\vec{\nabla}_q, \qquad \vec{W}^- = -i\hbar\left(\vec{p}\times\vec{\nabla}_p \ + \ \vec{q}\times\vec{\nabla}_q\right)$$

We find the eigenvalues and the eigenfunctions of these operators and we prove that the operators $W_i^- W_i^+$ and $\frac{1}{2}(W_i^- W_i^- + W_i^+ W_i^+)$, are the two independent Casimir invariants, of the Lie algebra of the Wigner angular momentum operators.