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Spin-1 quarkonia in a rotating frame and their spin contents

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We propose a new way of studying the spin content of a hadron by looking at its response in a rotating frame. By collecting all responses of quarks and gluons in a rotating frame, we describe the spin-rotation coupling of spin-1 quarkonia and thereby reveal their spin contents in a fully relativistic way. We demonstrate that both the perturbative and non-perturbative contributions in the operator product expansion follow a universal formula that identifies the spin-rotation coupling with unit strength. This allows us to recognize the total spin-1 of the vector and axialvector quarkonia in terms of the total angular momentum of quarks and gluons. Specifically, we find the spin contents of J/ψ, χ_{c1}, $\Upsilon(1S)$, and χ_{b1} are slightly different from the naive quark model picture. For example, the J/ψ is traditionally considered as an S-wave particle, but we find quarks do not carry all of the total spin.

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