

**Title:** Characterizations of a Lorentzian manifold with a semi-symmetric metric connection

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In this article, we characterize a Lorentzian manifold  $\mathcal{M}$  with a semi-symmetric metric connection. At first, we consider a semi-symmetric metric connection whose curvature tensor vanishes and establish that if the associated vector field is a unit time-like torse-forming vector field, then  $\mathcal{M}$  becomes a perfect fluid spacetime. Moreover, we prove that if  $\mathcal{M}$  admits a semi-symmetric metric connection whose Ricci tensor is symmetric and torsion tensor is recurrent, then  $\mathcal{M}$  represents a generalized Robertson–Walker spacetime. Also, we show that if the associated vector field of a semi-symmetric metric connection, whose curvature tensor vanishes, is an  $f$ -Ric vector field, then the manifold is a space of constant curvature. Therefore, the spacetime reduces to the Minkowski spacetime whenever the scalar curvature  $R = 0$ ; de Sitter spacetime whenever  $R > 0$ ; anti de Sitter spacetime whenever  $R < 0$ . Moreover, if the associated vector field is a torqued vector field, then the manifold becomes a perfect fluid spacetime. Finally, we apply this connection to investigate the Ricci solitons.

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