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Virasoro symmetry and integrability of shallow water approximations

We show that the following three systems related to various hydrodynamical approximations: the Korteweg–de Vries equation, the Camassa–Holm equation, and the Hunter–Saxton equation, have the same symmetry group and bihamiltonian structure. It turns out that their configuration space is the Virasoro group; and all three dynamical systems can be regarded as equations of the geodesic flow associated to different right-invariant metrics on this group or on an appropriate homogeneous space. We show that the above three cases in a sense exhaust all generic bihamiltonian systems related to the Virasoro group.