Summary: Many integrable systems can be reformulated as holomorphic vector bundles on twistor space. This is a powerful organizing principle in the theory of integrable systems. One shortcoming is that it is formulated at the level of the equations of motion. From this perspective, it is mysterious that integrable systems have Lagrangians. In this paper, we study a Chern-Simons action on twistor space and use it to derive the Lagrangians of some integrable sigma models. Our focus is on examples that come from dimensionally reduced gravity and supergravity. The dimensional reduction of general relativity to two spacetime dimensions is an integrable coset sigma model coupled to a dilaton and 2d gravity. The dimensional reduction of supergravity to two spacetime dimensions is an integrable coset sigma model coupled to matter fermions, a dilaton, and 2d supergravity. We derive Lax operators and Lagrangians for these 2d integrable systems using the Chern-Simons theory on twistor space. In the supergravity example, we use an extended setup in which twistor Chern-Simons theory is coupled to a pair of matter fermions.

MSC:
83C60 Spinor and twistor methods in general relativity and gravitational theory; Newman-Penrose formalism
83E50 Supergravity
81R12 Groups and algebras in quantum theory and relations with integrable systems
58J28Eta-invariants, Chern-Simons invariants

Keywords:
Chern-Simons theories; differential and algebraic geometry; integrable field theories; sigma models

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