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Toward automated discovery of analytical physical laws from data using deep reinforcement learning

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Symbolic Regression is the study of algorithms that automate the search for analytic expressions that fit data. With new advances in deep learning there has been much renewed interest in such approaches, yet efforts have not been focused on physics, where we have important additional constraints due to the units associated with our data.

I will present Φ-SO, a Physical Symbolic Optimization framework for recovering analytical symbolic expressions from physical data using deep reinforcement learning techniques. Our system is built, from the ground up, to propose solutions where the physical units are consistent by construction, resulting in compact, physical, interpretable and intellegible analytical models. This is useful not only in eliminating physically impossible solutions, but because it restricts enormously the freedom of the equation generator, thus vastly improving performances.

The algorithm can be used to fit noiseless data, which can be useful for instance when attempting to derive an analytical property of a physical model, and it can also be used to obtain analytical approximations to noisy data or even open up the black box that are neural networks. I will showcase our machinery on a panel of astrophysical cases ranging from high energy astrophysics to galactic dynamics, all the way to cosmology. I will then touch on our preliminary results in applying this type of approach to physical differential equations.

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