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Lorentz-Equivariant Geometric Algebra Transformers for High-Energy Physics

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Extracting scientific understanding from particle-physics experiments requires solving diverse learning problems with high precision and good data efficiency. We propose the Lorentz Geometric Algebra Transformer (L-GATr), a new multi-purpose architecture for high-energy physics. L-GATr represents high-energy data in a geometric algebra over four-dimensional space-time and is equivariant under Lorentz transformations, the symmetry group of relativistic kinematics. At the same time, the architecture is a Transformer, which makes it versatile and scalable to large systems. L-GATr is first demonstrated on regression and classification tasks from particle physics. We then construct the first Lorentz-equivariant generative model: a continuous normalizing flow based on an L-GATr network, trained with Riemannian flow matching. Across our experiments, L-GATr is on par with or outperforms strong domain-specific baselines.

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