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Atmospheric retrievals: from machine learning to quantum technologies

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The study of exoplanetary atmospheres traditionally relies on forward models to analytically compute an exoplanet's spectrum by fine-tuning numerous chemical and physical parameters. However, the high dimensionality of the parameter space often results in significant computational overhead. In this work, we introduce a novel approach to atmospheric retrieval, leveraging machine learning techniques accelerated by GPUs and TPUs, and ultimately, quantum technologies. This integration of novel technologies will be crucial for analysing data in the era when the Habitable Worlds Observatory (HWO) becomes operational. We propose a framework for extracting exoplanetary atmospheric features using Technologies like DCGANS, Transformers and quantum extreme learning machines (QELMs), which employ quantum systems as a black box for processing input data. For this last system, we demonstrate a fault-tolerant strategy suitable for near-term quantum devices and show its implementation on IBM Fez. The QELM architecture we present shows the potential of quantum computing in the analysis of astrophysical datasets and may, in the near-term future, unlock new computational tools to implement fast, efficient, and more accurate models in the study of exoplanetary atmospheres.

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