TokaLab: an open-access and open-source FAIR framework for tokamak synthetic diagnostics and inverse problems benchmarking

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The development and validation of computational methods for tokamak diagnostics, particularly in the context of inverse problems and data-driven approaches, are often limited by the lack of standardized and reproducible benchmarking practices. In this work, we present an open access and open-source FAIR (Findable, Accessible, Interoperable, Reusable) framework, implemented within TokaLab, for the systematic benchmarking of synthetic diagnostics and inverse problem methodologies.

The framework provides a structured environment to define benchmark cases combining forward models, synthetic diagnostic generation, and associated inverse reconstruction tasks. Each benchmark is fully specified in terms of mathematical formulation, input datasets, and quantitative evaluation metrics, enabling rigorous validation, verification, and cross-comparison across heterogeneous computational tools.

Emphasis is placed on diagnostically relevant inverse problems, such as plasma tomography and equilibrium reconstruction, where the integration of physics-based models and machine learning techniques is rapidly evolving. The proposed framework enables consistent comparison between traditional and AI-based approaches under controlled and reproducible conditions.

By adhering to FAIR principles and promoting tool-agnostic interoperability, the framework aims to foster transparency, reproducibility, and collaboration within the fusion diagnostics community. This effort supports the development of more reliable and comparable computational methods, ultimately contributing to improved interpretation of experimental data.