

# 基于独立注意力演化轨迹的复合故障热工机理溯源

## 摘要

针对 AP1000 核电厂在严重复合瞬态下由于强非线性关联导致的显著特征覆盖问题，提出了一种基于独立注意力度量的动态诊断架构。基于 AP1000 模拟程序 PCTTRAN，对同源强关联与跨系统弱关联复合工况下的注意力动态演化行为进行了对比分析。研究表明，该架构通过引入拓扑空间度量与独立激活机制，有效解除了传统判别模型的互斥性约束，精准分离了重叠的失水特征并切断了跨系统的间接热工干扰。研究结果可为 72 小时非能动观察窗口内的操纵员辅助决策提供透明、量化的物理依据。

## 关键词

核电厂；深度学习；复合故障；独立注意力

## Abstract

Significant feature masking occurs in AP1000 nuclear power plants due to strong nonlinear correlations during severe composite transients. To address this, this study proposes a dynamic diagnostic architecture based on independent attention metrics. The architecture was evaluated using the AP1000 simulation system PCTTRAN. A comparative analysis was conducted on the dynamic evolution of attention behaviors under composite conditions involving homologous strong correlations and cross-system weak correlations. While traditional discriminative models are restricted by mutual exclusivity constraints, the proposed architecture eliminates these barriers by incorporating topological space metrics and independent activation mechanisms. This approach enables the precise isolation of overlapping loss-of-coolant features and severs indirect cross-system thermal-hydraulic interference. These findings provide a transparent, quantified physical basis for operator decision support within the 72-hour passive observation window.

## Keywords

Nuclear power plant; Deep learning; Composite faults; Independent attention.

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