Introduction: Why Are Hard X Rays Generated in Some RFP Discharges, but not Others?

Fast Electron Confinement Greatly Improves Locally and Hard X Rays are Generated When Magnetic Tearing is Reduced via Current Profile Control

Fast electrons are generated within the magnetic island

- HIMs are detected whenever an island is present, which is detected using soft x rays that provide information about the island.
- An island can form from a localized runaway electron even if the dominant tearing modes are suppressed.
- When the dominant mode n is very large, even a small increase in normalized B or qmin on a q=0 surface causes the island to be stable.
- OHIFAR, a Hands-on-gauging center code, predicts that high energy runaway electrons will form in the inside of the island.
- HIMs are measured from the entire plasma volume, indicating that the runaway actually escapes from local and variable stochasticity throughout the plasma volume.


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• X-rays spectra can thus provide insight into the transport of runaway electrons.

However, radial transport can greatly reduce runaway production.

- It might be expected that the large loop voltage in MST ($E_L$ from fast electrons) will accelerate a large population of runaway electrons.

- Magnetic islands form on these surfaces; neighboring surfaces form inside the island. As with PPCD, x rays with energies up to 150 keV are detected in this case.

- New, faster shaping amplifiers and digitizers will provide improved time resolution on the island and diffuse throughout the plasma.

- An island may form and confine runaway electrons even if the dominant tearing modes are suppressed. Confinement is greatly improved.

- HIMs with energies as high as 150 keV are detected in this case.

- The QSH case, indicating that runaways form in the core region of the plasma and radial diffusion is no longer produced in this case.

- Fast electrons are exponentially localized to small areas with a form that depends on the primary mode of particle transport.

- The SXR detector was used for this fit, where the SXR detector is used for this fit.

- Normalized to the value obtained by the best fit.

- $r/a = 5$ m

Standard RFP Discharges have Poor Fast Electron Confinement and do not Generate Hard X Rays

- Large, central tearing modes develop on several surfaces.

- Confinement is poor: fast electrons are lost almost immediately, so X-rays are detected.

- In standard RFP discharges, island formation is dominated by stochastic transport.

- When the Fokker-Planck Code CQL3D is used to find rational surfaces, confinement of electrons is observed.

- The Fokker-Planck Code CQL3D can be used to find rational surfaces.

- HIMs cannot be used to model QSH plasmas since the island is in the core of the plasma.

- The HIMs produced by the island and diffuse throughout the plasma.

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Fast Electron Confinement Improves Locally and Hard X Rays are Generated When Magnetic Tearing is Reduced via Current Profile Control

- Magnetic islands no longer confine, and runaway electrons are produced from closed flux surfaces.

- Fast electrons are exponentially localized to small areas with a form that depends on the primary mode of particle transport.

- In standard RFP discharges, radial diffusion acts to reduce fast electron conduction.

- Magnetic islands no longer confine, closed flux surfaces re-emerge, and runaway electrons are produced.

- Fast electrons are exponentially localized to small areas with a form that depends on the primary mode of particle transport.

Conclusions: Hard X Rays are an Indicator of Decreased Stochasticity and Improved Confinement

- X-ray bremsstrahlung is generated when runaway electrons are produced.

- For soft x-ray detectors, a peak in the core, where good flux surfaces are produced, is used as an indicator of runaway electron production.

- For standard RFP discharges, x-ray bremsstrahlung is generated when runaway electrons are produced.

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Future Work: An Upgraded X-Ray Spectroscopy Diagnostic Will Provide Radially-Resolved Soft-X Ray Measurements

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- Normalized to the value obtained by the best fit.

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Without radial diffusion, standard RFP discharges would have a large runaway population

- In standard RFP discharges, island formation is dominated by stochastic transport.

- When magnetic tearing is reduced via current profile control, confinement is greatly improved.

- HIMs with energies as high as 150 keV are detected in this case.

- The HIMs produced by the island and diffuse throughout the plasma.

- Some HIMs are generated in the core region of the plasma and radial diffusion is no longer produced in this case.

- Fast electrons are exponentially localized to small areas with a form that depends on the primary mode of particle transport.

- The Fokker-Planck code CQL3D is used to find rational surfaces.

- HIMs cannot be used to model QSH plasmas since the island is in the core of the plasma.

- The HIMs produced by the island and diffuse throughout the plasma.

- All HIMs are measured from the entire plasma volume, indicating that the runaway actually escapes from local and variable stochasticity throughout the plasma volume.

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- HIMs are detected whenever an island is present, which is detected using soft x rays that provide information about the island.

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