LIGHTING NEW STARS

NovaFusion and the Claro-II Project: Twin Hinac (Dhinac) Toward Helium-3 Aneutronic Fusion

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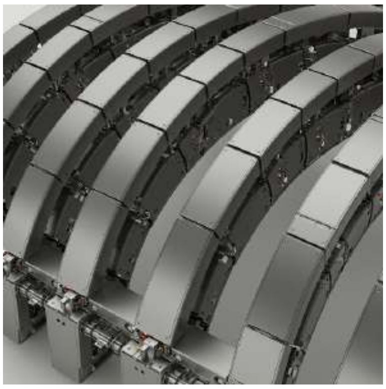
Introduction

In the race for clean fusion energy, the challenges posed by neutron emissions from deuterium-tritium (D-T) reactions are driving researchers toward safer alternatives. **NovaFusion**, through its **Claro-II project**, proposes an innovative solution: reconfigurable **twin helical accelerators (Dhinac)** to power deuterium-helium-3 (D-^{3}He) aneutronic fusion. This article explores how these *twin Hinac*, initially designed to accelerate electrons, are adapted for light ion injection, combining compactness and flexibility for a clean energy revolution.

Twin Hinac (Dhinac): A Dual Architecture

The **Dhinac** (*Double Helical Ion Accelerator*) integrates two helical accelerators (*Hinac*) spiraled around the core of the **Claro-II tokamak.** Designed to operate synergistically, these twin Hinac offer:

- **Redundancy and Power**: Doubling injection capacity enables **45 MW of plasma heating**, critical for achieving required high temperatures.
- **Flexibility**: One Hinac can dedicate itself to electrons (initial heating), while the other accelerates $^3He^+$ ions for the aneutronic phase.



Hinac Operation

- **Superconducting RF Cavities**: Made of niobium-tin (Nb_3Sn), they generate gradients of 25 MV/m for electrons or 10 MV/m for ions.
- **Modular Magnetic System**: Segments of YBCO superconducting ribbons arranged in a modular rheostatic system produce an adjustable axial magnetic field (1 to 5 T), tailored to particle mass.

D-^{3}He Fusion: Reducing Neutrons, Maximizing Efficiency

The deuterium-helium-3 reaction primarily produces energetic protons and helium-4, with nearly no neutron emission:
$D + {}^3He \rightarrow {}^4He$ (3.6 MeV) + p (14.7 MeV)
Key Advantages:

- **Direct Energy Conversion**: Protons are captured via electrostatic collectors (efficiency > 70%), bypassing inefficient thermal cycles.
- **Simplified Maintenance:** Reduced neutron flux minimizes reactor wall activation and material degradation.

Reconfiguring Hinac for Helium-3

1. Terrestrial Helium-3 Production

Helium-3, rare on Earth, can be synthesized via **neutron irradiation of lithium-6**:
$n + {}^{6}Li \rightarrow {}^{3}He$ (2.05 MeV) + ${}^{4}He$ (2.73 MeV)
This reaction, conducted in auxiliary reactors, fuels the Claro-II project.

2. Technical Adaptation of Hinac

- **ECRIS Ion Source**: An *electron cyclotron resonance ion source* produces ${}^{3}He^{+}$ beams at 100 mA.
- **Reinforced Windows**: Cubic boron nitride (c-BN) coated with nanocrystalline diamond resists 14.7 MeV protons.

The Claro-II Project: An Integrated Demonstrator

The **Claro-II tokamak**, with a **15-meter major radius**, integrates twin Hinac in a unique configuration:

- **Target Parameters**:
  - Ion temperature: 80 keV.
  - Plasma density: 2×10^{20} m^{-3}.
  - Heating power: 45 MW (22.5 MW per Hinac).

Roadmap

- **2027**: Testing of reconfigured Hinac **in partnership with NovaFusion** at the **EUROfusion research center**.
- **2030**: First D-${}^{3}He$ plasma in Claro-II.

Technical Challenges

1. **Proton Collector Shielding**:
   - 14.7 MeV protons demand radiation-resistant materials (e.g., lanthanum-doped tungsten).
2. **Lithium-6 Supply**:
   - Lithium-6, enriched to 95%, is extracted via energy-intensive isotopic distillation, now under optimization.

Prospects and Applications

- **Urban Power Plants**: 300 MW reactors deployable near residential areas.
- **Medical Isotope Production**: Fusion-generated protons synthesize ^{67}Ga for cancer imaging.

Conclusion

With the twin Hinac (Dhinac) and the Claro-II project, NovaFusion pushes the boundaries of aneutronic fusion. By combining operational flexibility, HTS superconductivity, and innovative fuel management, this concept could deliver clean, safe, and competitive energy by 2040.

NovaFusion / Louis-François Claro
Former Associate Professor, S.I.C. 71st Section, University of Lille
louisfrancoisclaro@gmail.com | Tel.: +33 6 07 96 81 87 | www.novafusion.fr

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Note: References exclude NovaFusion internal documents to ensure academic neutrality.

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