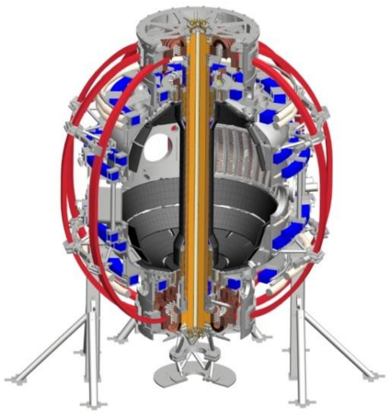
Chapter 1 (update the #)



Chapter title goes here

1.1 Level 1 – Main section heading – 20 pt bold

1.1.1 Level 2 - 16 pt bold

1.1.1.1 Level 3 – 14 pt bold

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Guidance for the formatting of your chapter:

- Chapter number font: Bold Italic 32pt
- Chapter title font: Bold 28pt
- Replace the figures above with something representative of your chapter
- Text font: Times New Roman
- Text font size: 12pt
- Text spacing: 1.15 using the Word line-spacing option
- Section heading fonts: see examples above
- Figure captions: 10pt italic, number according to the sub-section figure is in – see examples below. Put the Figure and caption in a single text-box – do not "group" them.
- References: Put at end of each chapter, "References" section heading should be in 16pt bold-face. See end of this template file for referencing style.

The Spherical Torus (ST) concept is a low-aspect-ratio tokamak magnetic configuration characterized by strong intrinsic plasma shaping and enhanced stabilizing magnetic field line curvature. These characteristics are shown pictorially in Figure 1.1.1. These unique ST [1,2] characteristics enable the achievement of a high plasma pressure relative to the applied magnetic field and provide access to an expanded range of plasma parameters [3] and operating regimes relative to the standard aspect ratio tokamak [4-8]. NSTX has demonstrated that ST's can access a very wide range of dimensionless plasma parameter space with toroidal beta β_t up to 40% (local $\beta \sim 1$), normalized beta β_N up to 7, plasma elongation κ up to 3, normalized fast-ion speed $V_{fast}/V_{Alfvén}$ up to 5, Alfvén Mach number $M_A = V_{rotation}/V_{Alfvén}$ up to 0.5, and trapped-particle fraction up to 90% at the plasma edge. All of these parameters are well beyond that accessible in conventional tokamaks, and these parameters approach those achievable in other high-β alternative concepts.

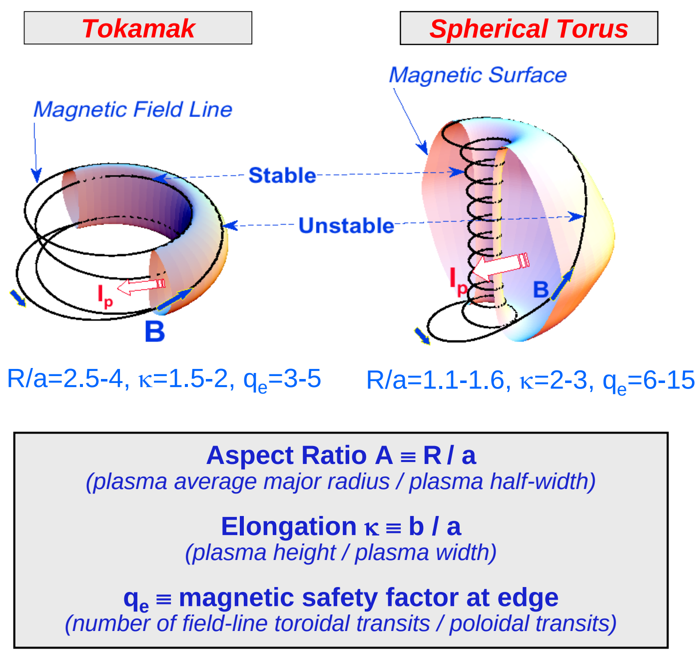

Figure 1.1.1: Comparison of magnetic field-line trajectories, aspect ratio, elongation, and safety factor parameters for a tokamak (left) and spherical torus (right).

These characteristics therefore allow ST research to complement and extend standard aspect-ratio tokamak science while providing low-collisionality, long pulse-duration, and well-diagnosed plasmas to address fundamental plasma science issues – including burning plasma physics in ITER. The ST addresses fundamental issues in magnetic fusion energy science in the areas of: macroscopic stability, turbulence and transport, wave-particle interactions, boundary physics, and solenoid-free current formation and sustainment. For fusion applications, the high β, compact geometry, accessibility, modularity, and simplified magnets of the ST are potential advantages for plasma material interaction studies at high heat flux, nuclear component testing, and for a fusion power reactor.

NSTX is the world's highest performance ST research facility and is the centerpiece of the U.S. ST national research program. As illustrated below in Figure 1.1.2, NSTX is an essential element in the program to advance the understanding and development of the ST concept while also complementing and accelerating the development of all DEMO concepts.

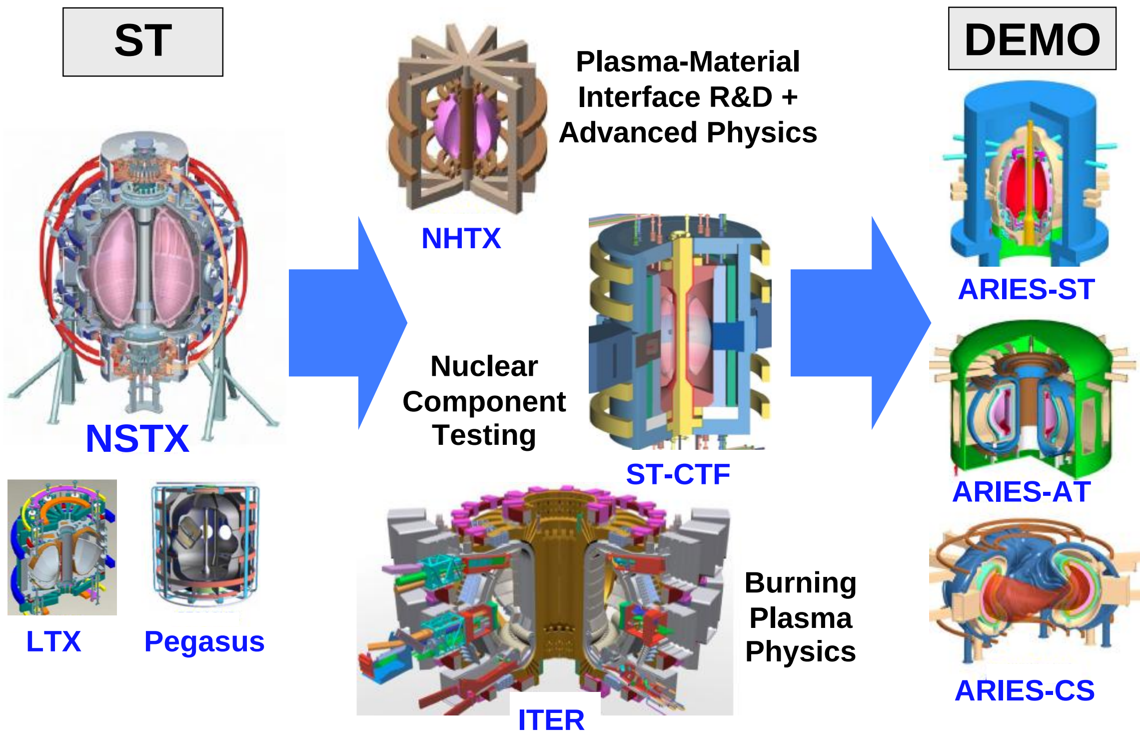

Figure 1.1.2: (left) U.S. ST research facilities, (middle) next-step STs to complement tokamaks and ITER burning plasma research by addressing key PMI and neutron fluence gaps between ITER and DEMO, and (right) spherical torus (ST), advanced tokamak (AT), and compact stellarator (CS) DEMO/reactor concepts developed by the ARIES reactor studies group (http://www-ferp.ucsd.edu/aries/).

The three overarching mission elements of the NSTX research program for 2009-2013 are:

(1) Determine the physics properties of the ST - utilizing its low aspect-ratio (A ~ 1.5) and very high ratio of plasma pressure to magnetic pressure (up to order-unity beta) - to advance toroidal plasma science.

(2) Provide unique ST data to the tokamak knowledge-base in support of ITER final design activities and preparation for burning plasma research in ITER through participation in the International Tokamak Physics Activity (ITPA) and U.S. Burning Plasma Organization (USBPO), while also benefiting from tokamak and ITER R & D.

(3) Develop the S…

The remainder of this chapter first describes the unique parameter regimes accessed in NSTX (Section 1.2) to provide context for understanding NSTX contributions to tokamak physics and ITER (Section 1.3) and, most importantly, for motivating fusion energy science applications of the ST (Section 1.4) and identifying scientific gaps (Section 1.5) and opportunities (Section 1.6). Section 1.7 briefly summarizes the NSTX 10 year scientific research objectives, and Section 1.8 describes the scientific organizational structure of the NSTX national research team.

1.2 Parameter Regimes Accessed by NSTX-U

1.2.1 Macroscopic Stability

The fundamental fusion advantage and scientific opportunity enabled by low aspect ratio A ≡ R/a (see Figure 1.1.1)

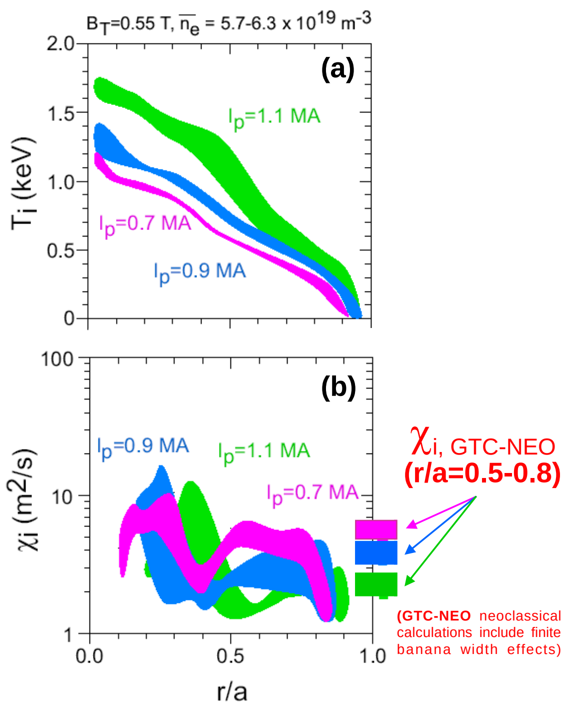

Figure 1.2.2.1: (a) Illustration of nearly linear dependence of ion temperature on I_P, and (b) consistency between measured ion thermal diffusivities and neoclassical predictions of the GTC-Neo code.

1.2.2 Transport and Turbulence

Just as the enhanced toroidicity (low aspect ratio) and increased natural shaping of NSTX plasmas can suppress macroscopic instabilities, these ST characteristics are also expected to

References

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