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Classification of Average Minimum-B Configurations

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The purpose of this note is not to propose a new configuration but to classify the average minimum-B configurations that have been proposed.

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I. INTRODUCTION

Many types of toroidal configurations have been proposed which have the properties called average minimum-B or negative-V". Some of them may look quite exotic. However, in closer examination, they may be classified in two geometrical variations and three physical variations.

II. GEOMETRICAL VARIATIONS

Geometrical variations are classified as Type A: having the maximum of plasma pressure on either elliptic type magnetic axis or a flux surface which is not a separatrix; Type B: having the pressure maximum on a separatrix. These classifications are closely related to the method by which average minimum-B is obtained.

In Type A the properties of a toroidal field, that the field strength decreases with radius, and the fact that the line length increases with radius, are exploited. Hence the smaller the aspect ratio, the deeper the magnetic well. A large magnetic shear is also the possibility, because of a small aspect ratio.

In Type B, the separatrix is inherently at the bottom of a magnetic well. Therefore a well may be obtained by using only poloidal magnetic

field. A toroidal field is incidental for the magnetic well but is essential for the forming of magnetic surfaces and for obtaining magnetic shears.

III. PHYSICAL VARIATIONS

Physical variations are due to the means by which elliptic magnetic axes or closed flux surfaces are produced. In Type I, it is done by internal conductors, in Type II, by plasma current, and in Type III, by a helical or axially nonsymmetric field.

Type I and II configurations may be axially symmetric while Type III cannot. Type I and III configurations may be produced entirely by current carrying coils, while in Type II configurations the plasma current may be controlled indirectly by varying externally applied electric field.

IV. COMBINATION

Since there are three physical types and two geometrical types, the combinations give six variations.

Type I-A

Levitron-Spherator⁽¹⁾

deep well and large shear

Type I-B

Multipoles⁽²⁾

closed line and deep well

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Type II-A

Tokamaks⁽³⁾ and Toroidal or Hard Core θ -Pinches⁽⁴⁾

moderate shear and well

Type II-B

Plasma Current Multipole⁽⁵⁾

large shear

Type III-A

Negative-V" Stellarators⁽⁶⁾ and Snake Stellarators⁽⁷⁾

moderate shear and well

Type III-B

Seedless Multipoles⁽⁸⁾

Types I-A, I-B, and II-A (low β) have been studied experimentally. They showed confinement times of 10 ~ 50 times Bohm. Types II-B and III-A are going to be tested experimentally in the near future. Some design studies are being done for Type III-A and III-B. The main difficulties are probably obtaining good communication between the good and bad region with a deep magnetic well. The effects of field errors may be more severe in these configurations.

At the moment, all possible combinations seem to have been proposed. It is quite possible that a new approach or a hybrid between these configurations may produce better configurations.

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