Effect of superbanana diffusion on fusion reactivity in stellarators

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The strong effect of superbanana diffusion on the fusion reactivity in stellarators is pointed out. Using a simple model of stellarator magnetic fields, the loss rate given by a simple random-walk estimate for the diffusion coefficient is proportional to a positive power (+7/2) of the ion energy, in the "1/nu" regime. The rate of repopulation by Coulomb scattering is proportional to a negative power (-3/2) of the ion energy, so the most energetic ions in the tail are most strongly depleted by superbanana diffusion. These tail ions are the most important for D-T fusion reactions, for ion temperatures relevant for fusion in magnetic confinement devices, since the peak of the reaction rate occurs at an ion energy considerably higher than thermal. The Fokker-Planck equation, including superbanana diffusion as well as energy scattering, is solved numerically for the tail ion distribution function. The computed energy distribution is used to obtain an integrated fusion reactivity, using a standard fit to the D-T reaction cross section. The effect of superbanana diffusion on the fusion reactivity is much stronger than its effect on energy confinement, which involves a lower energy moment than the fusion reactivity. A plot of reactivity vs loss rate shows that the fusion reactivity is greatly reduced due to loss by superbanana diffusion, unless the helical field ripple is very small.

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