On the Stability of Bahcall-Wolf Cusps of Dark Matter Orbiting Supermassive Black Hole Binary Systems

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The stability of Bachall-Wolf cusps of dark matter (DM) particles orbiting a supermassive black hole (SMBH) binary system was studied as the SMBHs lost energy through gravitational radiation and merged. The Paczynsky-Wiita approximation was used to model the motion of all objects, and additionally the (5/2) Post-Newtonian approximation modeled emission of gravitational radiation by the SMBHs. An adaptive stepper was implemented using the Cash-Karp method for a 5th-order Runge-Kutta approximation. DM particles were initialized from a Bahcall-Wolf distribution in stable orbits around one of the SMBHs, then the simulation was run until the SMBHs merged, tracking the position of each particle. After the SMBHs merged, 6% of the DM particles remained in stable orbits, while 23% were ejected from the SMBH system and 71% fell into one of the SMBHs. Analysis of the cusp structure over time revealed that the remaining stable particles were in orbits outside the initial orbit of the SMBHs, and the density of DM in those outer regions increased. The ejection of DM from the SMBH system may completely eject them from the galaxy, allowing nebulae to expand and cool, encouraging the formation of lighter mass stars, and making the galaxy more hospitable to life.

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