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ASTROPHYSICAL MAGNETIC FIELDS AND TOPICS IN GALAXY FORMATION

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Final Report on
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Astrophysical Magnetic Fields and Topics in Galaxy Formation

Introduction

The grant was used to support theoretical research on a variety of astrophysical topics falling broadly into those described by the proposal: galaxy formation, astrophysical magnetic fields, magnetized accretion disks in AGN, new physics, and other astrophysical problems. Work accomplished is summarized below; references are to work authored by project personell.

Galaxy Formation

Early reports of a strong IR background led to a study (1) of whether such a background could be produced by stellar energy in a forming galaxy, with negative results. On the other hand, it was realized that if such radiation exists, it could be the result of thermalization by dust — a process which would accompany galaxy formation by mock gravity (2); detailed calculations show that mock gravity would be effective only if the radiation field is even greater than that observed (3). In the same vein, it was shown that any infrared excess of the type claimed could not be due to decaying particles (4, 5). Brown dwarfs were shown to be plausible candidates for dark matter in galaxies, and their IR emission was calculated (6). It was found that normal dust at high redshift should be detectable with COBE. Other candidates were considered for the dark matter, including strange particles (7), domain walls (8), cold dark matter (9), massive neutrinos (10), technicolor charged particles (11), cosmic strings (12, 13), and textures (13).

Astrophysical Magnetic Fields

Current sheets in twisted magnetic fields were studied with zero plasma pressure (14, 15) and with finite plasma pressure (16). A model of AGN accretion disks was constructed employing magnetic fields accreted with the interstellar medium (17). Magnetic reconnection in a pair plasma (18) was shown to proceed at relativistic rates (19), while Petschek reconnection in non pair plasmas will accelerate particles at shocks (20). Fundamental issues plaguing the α-Ω dynamo theory of galactic magnetic fields were reviewed (21, 22), and it was shown that magnetized disks of a certain type do not form black holes (23). A suggestion which would lead to production of magnetic fields in the early universe was found not to work (24). Magnetic helicity in astrophysics was analyzed (35).

Magnetized Accretion Disks in AGN

Having shown that the x-ray background (XRB) cannot be due to hot intergalactic gas (9, 25, 26) it was argued that radiation by relativistic electrons in AGN magnetized accretion disks may be responsible for the XRB (27, 28, 29, 30, 31, 32, 33). However, this model predicted that AGN in general should emit gamma rays that are not observed, thereby favoring models in which the emitting particles are only mildly relativistic.

New Physics

Calculations were made on superconducting cosmic strings (34), coupling of electrodynamics to pseudoscalar fields (36, 37, 38, 39), time machines (40), and gravitational torsion (41). It was shown that cosmic strings can carry baryon number (43). A claim to have discovered astronomical evidence of coupling of electrodynamics with a pseudo-scalar field was shown to be wrong (44). A new model of fundamental interactions was proposed (49).

Other Astrophysical Problems

Progress was made on calculating the effect of rotation on a stellar system approaching the density in which stellar collisons would otherwise cause the formation of a black hole (45). A new way was proposed to determine the distances of high latitude HI clouds (46). The contribution of super dense molecular clouds to many of disk galaxies was explored (42). It was shown that a dusty torus will form naturally in a galactic nucleus harboring a black hole (47). A model of gamma-ray bursts was constructed, based upon relativistic beaming by a precessing neutron star (48). The theory of the interstellar medium was reviewed (50).

Personnel

Over the period of the grant, three undergraduates, five graduate students, a visiting graduate student and five postdocs were supported by the grant. Four of the graduate students completed the PhD; one is now employed in physics research, while the others are in industry. Four of the postdocs are in research, one in industry.

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