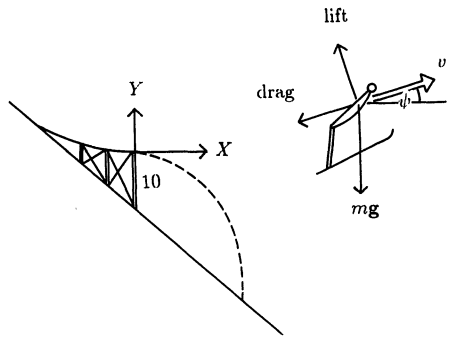

"Force diagram and jump profile for Nordic ski jump." The jumper "with his skis on has a mass of 70 kg, and his frontal area in the jumping position through the air is 0.7 m^2. At a certain jumping altitude the air density is 1.007 kg m^{-3} and the value of g is 9.81 ms^{-2}. If the drag and lift forces are proportional to the square of the speed with $C_D = 1.78$, $C_L = 0.44$ and if his velocity at the take-off point is 15 ms^{-1} in the horizontal direction, determine where he will land on the hill-slope whose angle is 45°. The take-off point is 10 metres vertically above the slope." [From *The Mathematics of Projectiles in Sport*]

problems involving the trajectories of various types of projectiles ranging from bombs to golf balls. Underlying all their calculations is a basic assumption: *air resistance can be neglected*.

Many years after I graduated, when I began to study the trajectories of sports projectiles, it came as something of a shock to me to discover that air resistance has a significant effect on the flight of almost any projectile. I felt considerable resentment toward my freshman physics instructor for not taking the trouble to mention this fact before we zipped along to the next chapter of Sears and Zemansky. In defense of this oversight, I should point out that when one does attempt to take air resistance realistically into account, the projectile motion equations turn out not to have analytic solutions, and must be solved numerically. My physics education took place in the days when we carried slide rules, rather than lap-top computers, to class every day.

Actually, the study of projectile motion through resisting media has a very long history. Contributions have been made by the likes of Galileo, Newton, Bernoulli, and Leibniz. However, work on this subject has, in the main, been in the service of the military; there is an extensive literature detailing methods for calculating the paths of cannonballs, bullets, artillery shells, and so on.

It is therefore a pleasure to report that the latest text in this line, *The Mathematics of Projectiles in Sport*, focuses the power of mathematics on the study of sports projectiles rather than on ways to destroy other human beings more efficiently. Its author, Australian mathematician Neville de Mestre, formerly of the Australian Defense Force Academy, now teaches at Bond University in Queensland. His stated aim is "to present a unified collection of the many problems that can be solved and of all the mathematical techniques that can be employed. . . . Emphasis here will be on the non-military applications of the behaviour of projectiles in flight, which have received only limited attention." De Mestre's aims are indeed admirable, and the work itself deserves considerable praise. This is a very readable, informative, and entertaining text, and its publication coincides most appropriately with the end of the Cold War.

As the title clearly states, this is a mathematics text; it is written for a reader who is comfortable with differential equations. The author begins by deriving in their most general forms the equations for projectile motion under gravity alone and then proceeds in an orderly fashion to the cases of linear drag (which lends itself to analytical solution, but has virtually no practical applications) and quadratic drag (which represents most aerodynamic forces, but must be solved numerically). Various approximation techniques are presented, and the effects of such factors as the Coriolis force, wind, density variations, and spin are also discussed. De Mestre's approach is to develop the mathematics up to the point where numerical integration becomes necessary, whereupon he leaves it to the reader to devise the numerical methods.

The development proceeds in a succinct, lively manner, with real-world references presented wherever possible. A particularly helpful touch is the inclusion of solved problems in the text, in addition to a set of exercises for the reader at the end of each chapter.

The last chapter of the book deals with specific applications to a wide range of sports projectiles. These have a distinctly Australian flavor; there are more references to rugby, soccer, and cricket than to American football or baseball (it was interesting to learn that whereas an American football is spiralled, a rugby football is torpedoed). There is also a solved problem on the jumping distance of a kangaroo (p. 83) as well as an exercise on a gumboot throwing contest, whatever that is (p. 76).

In short, anyone who does projectile motion calculations will be extremely pleased by de Mestre's efforts. Ten years ago, when I set out to write a computer code to calculate baseball trajectories, I spent a lot of time plowing through obscure journals and texts trying to glean information on solution techniques from a rather disjointed literature. I wish de Mestre's book had been around then; it would have been of enormous help. But I suspect that at that time it probably would have had more references to bullets than to baseballs.

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Stellar Dynamics

Dynamics of Dense Stellar Systems. DAVID MERRITT, Ed. Cambridge University Press, New York, 1989. xii, 251 pp., illus. $49.50. From a workshop, Toronto, Ontario, May 1988.

This book offers a long-needed survey on the kinematics and dynamics of the central—and densest—parts of galaxies and globular clusters. Although the structure of those objects has been a subject of detailed study for a long time, reliable results have only recently begun to appear. There are several reasons why dense stellar systems attract a lot of attention. First, they have comparatively short relaxation times, which makes them ideal objects for checking different theories of dynamics and evolution of stellar systems. Second, the central parts of dense stellar systems form a stage where various forms of activity are played out. And finally, it would not be an exaggeration to say that, among the reasons that astronomers and physicists are so enthusiastic about dense stellar systems, one is especially tantalizing: the evolution of these systems seems to be a natural way to the formation of massive or even supermassive black holes. Indeed, it was the discussions related to this topic that I found most interesting in *Dynamics of Dense Stellar Systems*.

Some important differences should exist between the evolution of globular clusters and galactic nuclei, and, in fact, available data on x-ray sources in globulars has demonstrated that they do not contain black holes—at least, not very massive ones (although in the mid-1970s there was a widespread belief that some of them did). Meanwhile, nuclear star clusters in normal galaxies, not to mention active galactic nuclei and quasars, seem to be ideal sites for harboring supermassive black holes of 10^6 to 10^9 solar masses.

A supermassive black hole within the nuclear star cluster of a normal galaxy can be disclosed by an increase of two important values—mass-to-luminosity ratio and stellar velocity dispersion—toward the galactic center. Unfortunately, evidence of this kind is not unambiguous. Even if the stellar distribution around the center is isotropic, the presence of another stellar population such as faint stars could mimic a black hole. In fact, often there is no isotropy at all; fast rotation found for some nuclear star clusters may indicate that they are disk-like. Moreover, such disks could even be strongly bar-like, and if such a bar is seen end-on the observer will measure star velocities near the pericenters of very elongated orbits so that the velocities turn out to be much larger than the circular velocities at the same radius. Ignoring this effect would lead to an overestimation of the mass. It may be that the large mass-to-luminosity ratios found for some nuclear star clusters that have been interpreted in the literature as evidence for central supermassive black holes are—at least a part of them—due to this effect.

Even if a large mass-to-luminosity ratio is real, the presence of a black hole is still not the only explanation. An alternative explanation could be the presence of a cluster of dark stars, either of massive stellar remnants or of low-mass stars. Distinguishing between these alternatives could be an experimental task for the Hubble Space Telescope. New observational data coupled with detailed modeling of nuclear star clusters would lead to more reliable conclusions as to whether or not the nearby galaxies contain central black holes.

It would be very instructive to find out whether our own galaxy harbors a central black hole. The center of the Galaxy (being about 100 times closer to us than our nearest neighbor, the Andromeda galaxy) provides evidence for a black hole with a mass not exceeding a few million solar masses. Again, this evidence from stellar dynamics is suggestive but not fully convincing, and some other approaches indicate that the upper limit could be smaller by a factor of 10^2 to 10^4.

The above-mentioned problems of stellar system dynamics related to the presence of central black holes provide intellectual stimulus for a substantial fraction of the volume. But in the remainder readers can find no less fun associated with more traditional topics of stellar dynamics, mostly dealing with the specific conditions of dense environments. Some of these issues are: stellar systems with negative temperatures, various aspects of dynamical evolution of dense stellar systems, solving the collisional Boltzmann equation in general relativity, globular clusters in a pre- and post-collapse state, stellar collisions in dense stellar systems, binary stars and their influence upon the evolution of dense systems, and gravothermal processes in N-body systems.

As with many volumes based on workshop talks, this book suffers from the brevity of some papers, but gains in both the variety of topics covered and approaches taken. Most of the volume should be very helpful to research scientists and graduate students, who will find in it a lot of subjects for novel investigation, both theoretical and observational. For instance, there are many unresolved issues pertaining to the topic of late evolution of globular clusters and especially of galactic nuclei. Although vigorous development of the field may make unavoidable some aging of its content, this book will retain for a long time the charm of an initial period of work in the fascinating boundary domain between astrophysics and stellar dynamics.

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Complexities of Ecology

The Ecology of Bird Communities. JOHN A. WIENS. Cambridge University Press, New York, 1990. In two volumes. Vol. 1, Foundations and Patterns. xiv, 539 pp., illus. $80. Vol. 2, Processes and Variations. xii, 316 pp., illus. $65.50. Cambridge Studies in Ecology.

In 1969, when John Wiens published his first major work on avian communities in *Ornithological Monographs*, community ecology was a growing discipline whose practitioners were full of optimism. The work of Robert MacArthur and his colleagues had established in the minds of many ecologists that the ecology of communities of plants and animals could be understood by appealing to a small number of general principles deduced from mathematical models of biological populations. MacArthur's favorite study organisms were birds, and his doctoral dissertation on wood warblers, published in 1958, had become a model study. By 1975, a consensus had developed among community ecologists regarding the interpretation of patterns in biological communities. Thomas Schoener's review of resource partitioning published in *Science* the year before stated the major conclusion of this consensus: that the differences in use of food and habitat by organisms of different species within a community were the result of competition between species for limited resources. The relative abundances of species in a community could be understood, and in some cases predicted, from the application of this simple idea.

It has been nearly three decades since MacArthur published his first paper, and the field of community ecology has witnessed a virtual explosion of research. In *The Ecology of Bird Communities*, Wiens reviews the substantial body of this research that deals with birds. The size of his review is a good indication of how popular the field of avian community ecology has become. One of the major themes underlying this monumental effort is the necessity of examining exciting ideas in the cold, hard light of data. Wiens argues that many of the ideas generated during the years when MacArthur had such a great influence over the development of community ecology, though logically sound, have not fared well when examined by rigorous field studies. To make this point, he spends two chapters in volume 1 discussing general principles underlying the collection, analysis, and interpretation of ecological data. He then examines many of the patterns that were used as validation of the ideas generated during the MacArthur period and suggests time and again that these ideas were either not supported by the results of field studies or not adequately tested. These empirical problems led community ecology into a decade of intense controversy.

At the center of the controversy documented by Wiens were two related ideas. The first was that competition is the major process determining the properties of species in a community. The second was the question of whether communities can be regarded as deterministic systems, as MacArthur had envisioned them, or whether they are "random" associations of organisms independently undergoing their life histories. These two ideas, and many corollaries of them, are discussed in volume 1 as Wiens reviews patterns documented by avian ecologists. Wiens concludes that to test these ideas rigorously, long-term, intensive studies of bird populations are necessary. Results obtained from studies such as those done by Peter Grant and his colleagues on the finches of the Galapagos Islands indicate that, although nature is more complex than the simple models of MacArthur allowed, there is at least some support for competition and deterministic processes as causes of observed patterns. The majority of the studies that Wiens reviews, however, are the results of one to at most three years of fieldwork, usually during the breeding season. Wiens maintains a healthy kepticism about the ability of such studies to rigorously test causal hypotheses because many of the processes that give rise to observed patterns are resolved on time scales much longer than two or three years.

In volume 2 Wiens deals with the difficult problem of explaining the patterns in bird communities that ecologists have documented. Interspecies competition is given considerable attention. After a careful review of definitions, Wiens examines the kinds of evidence that have been used to test hypotheses regarding competition. He concludes, "A good deal of the evidence that has been offered in support of the view that