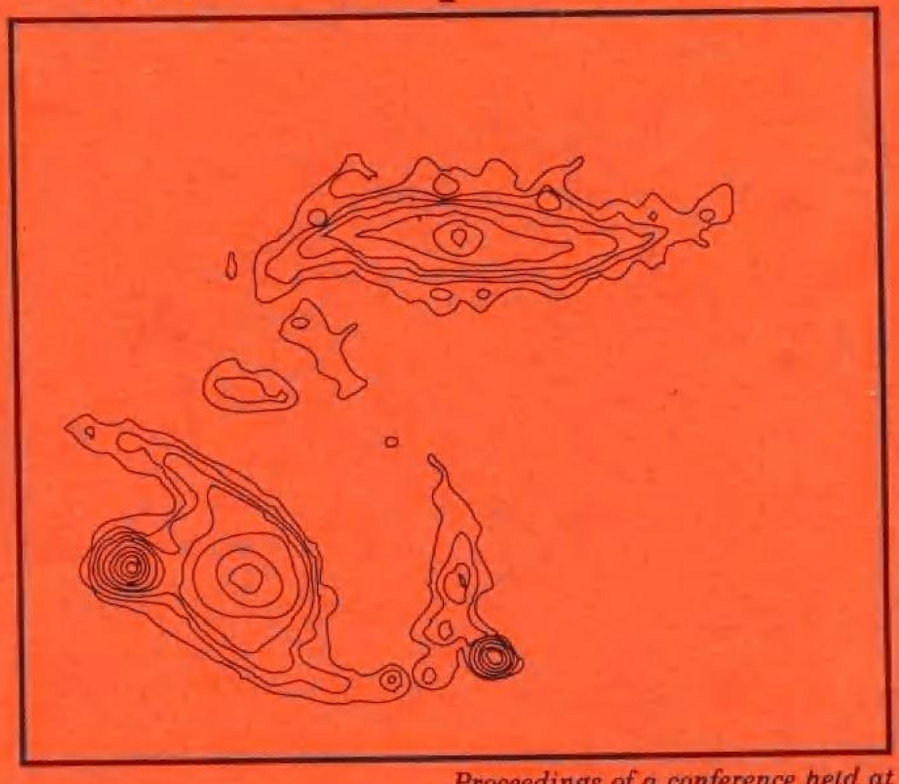
NASA Conference Publication 3098

Paired and Interacting Galaxies

International Astronomical Union Colloquium No. 124



Proceedings of a conference held at
the University of Alabama at Tuscaloosa
Tuscaloosa, Alabama
December 4–7, 1989

NASA

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Paired and Interacting Galaxies

International Astronomical Union Colloquium No. 124

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PREFACE

The subject labeled "interacting galaxies" is an unusual research area in the sense that many people work in it but rather few focus all of their effort in that area. The study of galaxies in pairs and groups is undeniably attractive. They represent some of the most beautiful and flamboyant examples of classical physics in action. Few can forget their first view of the "Cartwheel system" on the negatives of the ESO Sky Survey. The pairs and groups command our attention at other wavelengths, as well, because their enhanced emission frequently places an abundance of them in flux–limited samples. Ultimately, however, we study interacting systems because we hope that investigations of galaxies in nonequilibrium states will provide fundamental insights into their physical properties. As Chip Arp pointed out in the introduction to the Atlas of Peculiar Galaxies (1966) "if we could analyze a galaxy in the laboratory, we would deform it, shock it, probe it in order to discover its properties".

The motivation for IAU Colloquium #124 was to bring together theorists and observers, from a diverse array of specializations and wavebands, to summarize the current state of our knowledge of galaxies in pairs. The hope was to stimulate a confrontation between theorists and observers so that each group could fully understand the needs of the other. The conference attempted to cover both classical problems associated with the study of pairs such as sample selection, classification and dynamical modeling. Much time was also devoted to problems connected with understanding the effects of interaction upon individual galaxies in such systems. This topic embraces most of extragalactic astronomy, from ideas about star formation to the origin of the AGN phenomenon. We decided to include studies of compact groups of galaxies in the program since many of the observational and theoretical ideas about them relate to pairs as well. Much recent work has been done on these $n \geq 4$ systems and they represent a special challenge to dynamical theory.

The Astronomy group in the Department of Physics and Astronomy at the University of Alabama was pleased to host this conference. Astronomical activity began very early at this University (1844), cut short by political upheaval, but only within the last ten years has a significant research program emerged. A considerable fraction of this activity involves studies of pairs and groups, hence the decision to organize a conference on that topic at this place and time.

We thank the many individuals who assisted with the organization and success of this conference. We especially thank the scientists who attended the conference and who contributed such an impressive array of ideas and observations.

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I. CLASSICAL OBSERVATIONS

OF

PAIRS

A HOMOGENEOUS SAMPLE OF BINARY GALAXIES: BASIC OBSERVATIONAL PROPERTIES

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ABSTRACT

A survey of optical characteristics for 585 binary systems, satisfying a condition of apparent isolation on the sky, is presented. Influences of various selection effects distorting the average parameters of the sample are noted. The pair components display mutual similarity over all the global properties: luminosity, diameter, morphological type, mass-to-luminosity ratio, angular momentum etc., which is not due only to selection effects. The observed correlations must be caused by common origin of pair members. Some features (nuclear activity, color index) could acquire similarity during synchronous evolution of double galaxies.

Despite the observed isolation, the sample of double systems is seriously contaminated by accidental pairs, and also by members of groups and clusters. After removing false pairs estimates of orbital mass-to-luminosity ratio range from 0 to 30 $f_\odot$, with the mean value (7.8 ± 0.7) $f_\odot$. Binary galaxies possess nearly circular orbits with a typical eccentrity $e = 0.25$, probably resulting from evolutionary selection driven by component mergers under dynamical friction. The double-galaxy population with space abundance 0.12 ± 0.02 and characteristic merger timescale $0.2\ H^{-1}$ may significantly influence the rate of dynamical evolution of galaxies.

1. INTRODUCTION

Every year interest increases in investigating the structure and dynamics of systems of galaxies. The main stimulus here is the search for "missing" virial mass in these systems, which gives this problem somewhat of a detective nature. In the wide range of hidden mass searches pairs occupy an important place, as the simplest of galactic systems. Investigation of pairs allows us to approach the hidden mass problem at an elementary, "cellular", level. Binary galaxies are also especially interesting because of the accelerated rates of evolution as compared to solitary ones. Because of galaxies' mutually proximity in pairs, gravitational tides play a major part in their fate, star-formation bursts and dynamical friction effects. There are grounds to think that pairs significantly influence the dynamical evolution of galactic systems in general.

The first systematic studies of double galaxies were carried out by the Swedish astronomers Lundmark (1927) and Holmberg (1937, 1954), who suggested quantitative definitions of binary systems. Further progress in this study was achieved by Page. He made the first systematic measurements of radial velocities in binaries and worked out mass cal-

culation methods with different assumptions on the kind of orbital motions in pairs (Page 1952, 1960, 1967).

Zwicky *et al.* (1961-1968) and Vorontsov-Velyaminov *et al.* (1962-1968) compiled extensive galaxy catalogs, in which among others numerous examples of close binary systems are marked. Impressive collections of peculiar and interacting pairs are represented in the atlases by Arp (1966) and Vorontsov-Velyaminov (1959,1977). But in these catalogs, the binary galaxies do not form homogeneous samples because quantitative criteria had not been used in their selection. The pairs were selected according to strong signs of interaction as by-products of the main program. In time, the necessity of having a new double-galaxy catalog became apparent. It should be characterized by homogeneous observational data and be based on strict selection criteria of isolated pairs. Such a task was set by the author and realized in the form of the "Catalogue of isolated pairs of galaxies in the northern hemisphere" (Karachentsev, 1972). When preparing the catalogue, including 603 pairs, we kept a rule to inspect in detail the neighborhoods of all galaxies brighter than a fixed photometric limit, using the POSS prints. The search and selection of isolated binary systems was based on quantitative criteria for measuring mutual distances and angular diameters of the galaxies. A similar approach was used later by Turner (1976), Peterson (1979) and Schweizer (1987). According to our criterion, two galaxies with apparent magnitudes

$$m_1, m_2 < 15.7,$$

angular diameters a_1, a_2, and angular separation X are isolated relative to neighboring (in projection) galaxies, when the conditions

$$\mathrm{X}_{1i}/\mathrm{X}_{12} > 5a_i/a_1,$$

$$\mathrm{X}_{2i}/\mathrm{X}_{12} > 5a_i/a_2,$$

are satisfied ; i denotes any "significant" neighbouring galaxy, whose angular diameter a_i lies in the interval

$$4a_1 > a_i > a_1/2,$$

$$4a_2 > a_i > a_2/2,$$

Without going into detail, we may say that this criterion selects double systems with local density contrast on the sky more than 25.

Mass radial velocity measurements in isolated pairs aiming to study the kinematics and dynamics of double galaxies were undertaken (Karachentsev, 1980, Tifft, 1982). As a result of the combined efforts of several observers the program of radial velocity determination had been completed by 1983. Compared to previous episodic observations of galaxies in pairs, higher accuracy of radial velocity measurements was achieved, which allowed determination of masses of double systems with greater reliability.

After reduction of apparent magnitudes and angular diameters of galaxies to a standard system, specifying morphological and spectral types (and also excluding 18 single objects) the final version of the catalog was published in the book "Binary galaxies" (Karachentsev, 1987).