Arp Galaxy Study Guide

Hubble Space Telescope Images of Arp Galaxies:

(click on the links to observe)

Arp 26 (Messier 101)	Arp 188 (The Tadpole)
Arp 29 (NGC 6946 - IR)	Arp 217 (NGC 3310)
Arp 37 (Messier 77)	Arp 210 (NGC 1569)
Arp 85 (Messier 51)	Arp 220 (IC 4553)
Arp 87 (NGC 3808 group)	Arp 226 (NGC 7252)
Arp 120 (NGC 4438)	Arp 242 (The Mice)
Arp 152 (Messier 87 Jet)	Arp 244 (The Antennae)
Arp 153 (NGC 5128)	Arp 319 (Stephan's Quintet)
Arp 154 (NGC 1316)	Arp 336 (Messier 82)

Useful Summaries to Help Find Arps:

Arps in other catalogs: Messier, Herschel 400, and Hickson.
83 bright Arps (90 galaxies) in the Revised Shapley-Ames.
All 338 Arp Fields in Arp sequence.
All Galaxies involved in the 338 Arps by Right Ascension
Arps Sorted by Constellation.
Irregularities in identifying the galaxies involved in the Arps.
Where The Arps Are, a plot of locations in RA and Dec.
Magnitude Distribution of the brightest galaxies in each Arp.

Spectacular amateur color CCD images of Arps

Selected images posted by hard-working astrophotographers:

Randy Brewer	Arp 214 (NGC3718) Arp 77 (NGC 1097)
Ken Crawford	Arp 84 (NGC 5394 and 5395) Arp 188 (The Tadpole)
Russell Croman	Arps 133 and 308 (in Abell 194) Arp 244 (The Antennae) Arp 316 in Hickson 44
Robert Gendler	Arp 26 (Messier 101) Arp 85 (Messier 51) Arps 214 and 322 Arp 319 (Stephan's Quintet)
Don Goldman	Arps 79 and 117 Arp 245 (NGC 2992 group)

	Arp 273 (UGC 1810)
Al Kelly & Arne Henden	Arp 214 NGC 3718 Arp 295
Johannes Schedler	Arp 185 (NGC 5128) Arp 319 (Stephan's Quintet) Arp 281 (The Whale)
Volker Wendel & Bernd Flach-Wilken	Arp 120 (Copeland's Eyes) Arp 216 (NGC 1316)

The Arp Atlas of Peculiar Galaxies to purchase http://www.willbell.com/HANDBOOK/arp.htm

http://arpgalaxy.com/

http://en.wikipedia.org/wiki/Arp_273

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wikipedia fare use

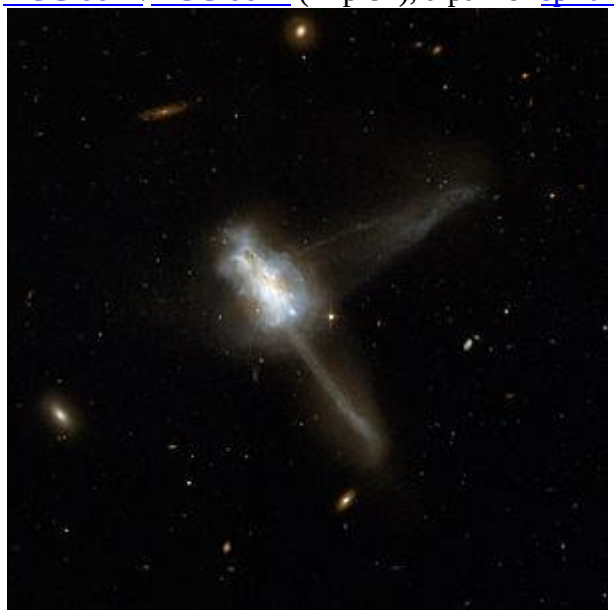
Atlas of Peculiar Galaxies

From Wikipedia, the free encyclopedia

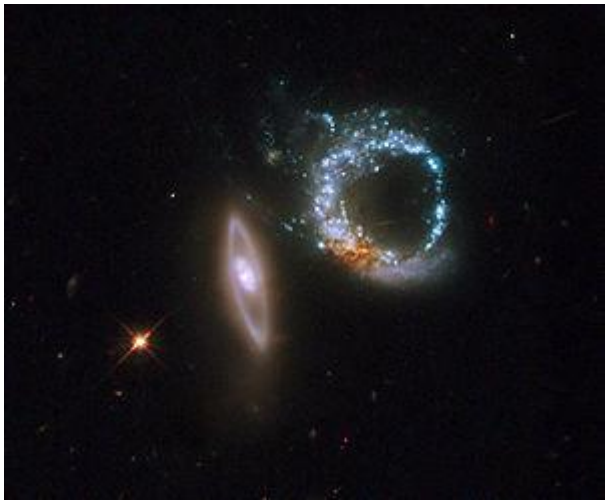
The Antennae Galaxies (Arp 244)

Colliding spiral galaxy pair NGC 3808A and NGC 3808B (Arp 87).

NGC 6621/NGC 6622 (Arp 81), a pair of spiral galaxies 100 million years after their colliding.



IC 883 (Arp 193), remnant of two galaxies' merger.



Arp 147, an interacting pair of ring galaxies.

The **Atlas of Peculiar Galaxies** is a catalog of peculiar galaxies produced by Halton Arp. A total of 338 galaxies are presented in the atlas, which was originally published in 1966 by the California Institute of Technology.[1]

The primary goal of the catalog was to present photographs of examples of the different kinds of peculiar structures found among nearby galaxies. Arp realized that the reason why galaxies formed into spiral or elliptical shapes was not well understood. He perceived peculiar galaxies as small "experiments" that astronomers could use to understand the physical processes that distort spiral or elliptical galaxies. With this atlas, astronomers had a sample of peculiar galaxies that they could study in more detail. The atlas does not present a complete overview of every peculiar galaxy in the sky but instead provides examples of the different phenomena as observed in nearby galaxies.

Because little was known at the time of publication about the physical processes that caused the different shapes, the galaxies in the atlas are sorted based on their appearance. Objects 1–101 are individual peculiar spiral galaxies or spiral galaxies that apparently have small companions. Objects 102–145 are elliptical and elliptical-like galaxies. Individual or groups of galaxies with neither elliptical nor spiral shapes are listed as objects 146–268. Objects 269–327 are double galaxies. Finally, objects that simply do not fit into any of the above categories are listed as objects 332–338. Most objects are best known by their other designations, but a few galaxies are best known by their Arp numbers (such as Arp 220).

Today, the physical processes that lead to the peculiarities seen in the Arp atlas are now well understood. A large number of the objects are interacting galaxies, including M51 (Arp 85), Arp 220, and the Antennae Galaxies (NGC 4038/NGC 4039, or Arp 244). A few of the galaxies are simply dwarf galaxies that do not have enough mass to produce enough gravity to allow the galaxies to form any cohesive structure. NGC 1569 (Arp 210) is an example of one of the dwarf galaxies in the atlas. A few other galaxies are radio galaxies. These objects contain active galactic nuclei that produce powerful jets of gas called radio jets. The atlas includes the nearby radio galaxies M87 (Arp 152) and Centaurus A (Arp 153).

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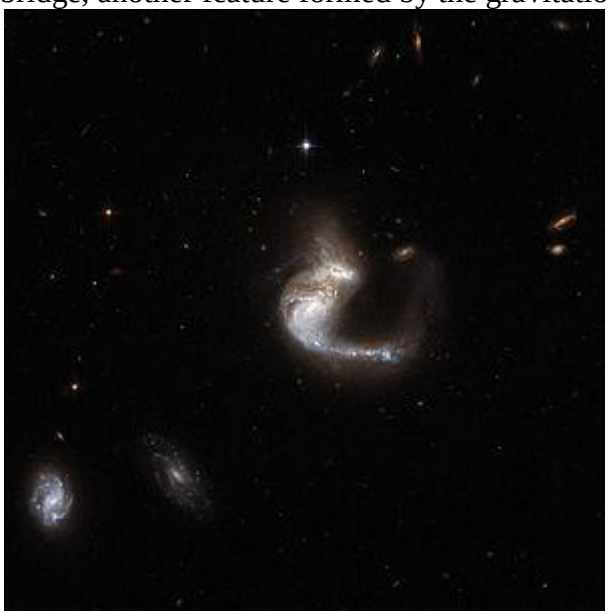
Notable Arp galaxies

The Mice Galaxies (NGC 4676; Arp 242). These two galaxies both have tidal tails that form as a consequence of the galaxies' gravitational interaction. The galaxies are also connected by a tidal bridge, another feature formed by the gravitational interaction.



Merging galaxy pair *"The Grasshopper"* (alias UGC 4881, FUDGE, Arp 55).

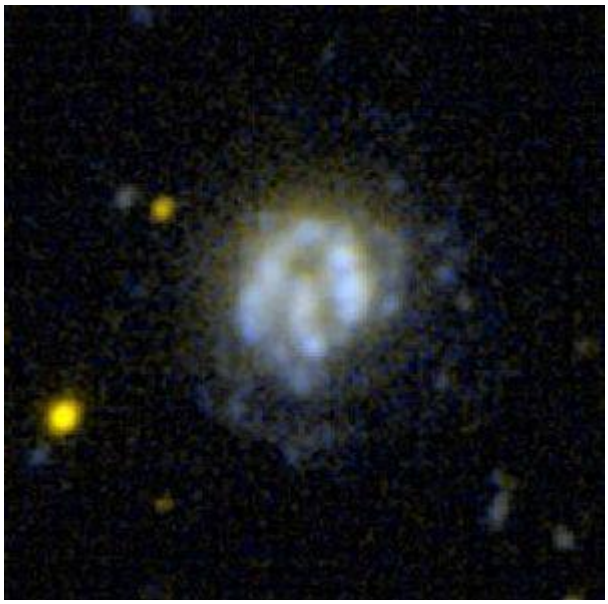
Arp Number	Name	Magnitude	Notes
26	Pinwheel Galaxy (M101)	+7.5	spiral galaxy
37	Messier 77	+8.9	radio galaxy
41	NGC 1232	+9.8	spiral galaxy
76	Messier 90	+9.5	spiral galaxy
77	NGC 1097	+9.5	galaxy interacting with its satellite
85	Whirlpool Galaxy (M51)	+8.4	galaxy interacting with its satellite

116	Messier 60	+8.8	colliding galaxies
152	Virgo A (M87)	+8.6	elliptical galaxy
153	Centaurus A (NGC 5128)	+6.6	radio galaxy in a collision?
188	Tadpole Galaxy	+14.4	galaxy finishing merging
242	Mice Galaxies	+14.7	colliding galaxies
244	Antennae Galaxies	+10.3	colliding galaxies
317	Messier 65	+9.2	spiral galaxy
319	NGC 7320	+15	galaxy in colliding group
337	Cigar Galaxy (M82)	+8.6	starburst galaxy

List of galaxies in the catalog

Spiral galaxies

Low surface brightness galaxies



Ultraviolet image of NGC 2537 (Arp 6)

These are mostly dwarf galaxies or poorly defined spiral galaxies (with the designation Sm) that have low surface brightnesses (i.e. they emit little light per unit area). Low surface brightness galaxies are actually quite common. The exception is NGC 2857 (Arp 1), which is an Sc spiral galaxy (which means that it has a definite structure with loosely-wound spiral arms and a faint but well-defined nucleus).[2]

Arp Number	Common Name	Notes
1	NGC 2857	Sc spiral galaxy[2]
2	UGC 10310	

3	Arp 3
4	Arp 4
5	NGC 3664
6	NGC 2537

Galaxies with split arms

This category contains spiral galaxies with arms that split into two separate parts.

Arp Number	Common Name	Notes
7	Arp 7	
8	NGC 497	
9	NGC 2523	
10	UGC 1775	Contains an off-center nucleus
11	UGC 717	
12	NGC 2608	

Galaxies with detached segments

M66 (Arp 16)

This category contains spiral galaxies with arms that appear to be segmented. Some spiral arm segments may appear detached because dust lanes in the spiral arms obscure the arms' starlight. Other spiral arms may appear segmented because of the presence of bright star clusters (or discontinuous chains of bright star clusters) in the spiral arms.

Arp Number	Common Name	Notes

13	NGC 7448
14	NGC 7314
15	NGC 7393
16	M66
17	UGC 3972
18	NGC 4088

Three-armed spiral galaxies

Usually, most spiral galaxies contain two clearly defined spiral arms, or they contain only fuzzy filamentary spiral structures. Galaxies with three well-defined spiral arms are rare.

Arp Number	Common Name	Notes
19	NGC 145	
20	UGC 3014	
21	Arp 21	

One-armed spiral galaxies

Ultraviolet image NGC 4618 (Arp 23)

One-armed spiral galaxies are also rare. In this case, the single spiral arm may actually be formed by a gravitational interaction with another galaxy.

Arp Number	Common Name	Notes
22	NGC 4027	
23	NGC 4618	Interacting with NGC 4625[3]

24	NGC 3445	

Spiral galaxies with one heavy arm

NGC 6946 (Arp 29) spiral galaxy

The spiral arms in these galaxies have an asymmetric appearance. One spiral arm may appear to be considerably brighter than the other. In the photographic plates produced by Arp, the bright arm would look dark or "heavy". While most of these galaxies (such as M101 and NGC 6946) are simply asymmetric spiral galaxies, NGC 6365 is an interacting pair of galaxies where one of the two galaxies is viewed edge-on and just happens to lie where the spiral arm for the other face-on galaxy would be visible.[4]

Arp Number	Common Name	Notes
25	NGC 2276	
26	M101	Face-on spiral galaxy with five notable companion galaxies[3]
27	NGC 3631	
28	NGC 7678	
29	NGC 6946	
30	NGC 6365	Interacting pair of galaxies, with one galaxy viewed edge-on[4]

Integral sign spiral galaxies

These are galaxies that look like a stretched-out S shape (or like the integral sign used in calculus). Some objects, such as IC 167,[5] are simply ordinary spiral galaxies viewed from an unusual angle. Other objects, such as UGC 10770, are interacting pairs of galaxies with tidal tails that look similar to spiral arms.[6]

Arp Number	Common Name	Notes

31	IC 167
32	UGC 10770
33	UGC 8613
34	NGC 4615
35	UGC 212
36	UGC 8548

Spiral galaxies with low surface brightness companions

Many of these spiral galaxies are probably interacting with the low surface brightness galaxies in the field of view. In some cases, however, it may be difficult to determine whether the companion is physically near the spiral galaxy or whether the companion is a foreground/background source or a source on the edge of the spiral galaxy.

Arp Number	Common Name	Notes
37	M77	
38	NGC 6412	
39	NGC 1347	
40	IC 4271	
41	NGC 1232	
42	NGC 5829	
43	IC 607	
44	IC 609	
45	UGC 9178	Galaxy triplet[7]
46	UGC 12665	
47	Arp 47	
48	Arp 48	

Spiral galaxies with small high surface brightness companions

Image of NGC 1097 (Arp 77) spiral galaxy

Again, many of these spiral galaxies are probably interacting with companion galaxies, although some of the identified companion galaxies may be foreground/background sources or even bright star clusters within the individual galaxies.

Arp Number	Common Name	Notes
49	NGC 5665	
50	IC 1520	
51	Arp 51	
52	Arp 52	
53	NGC 3290	
54	Arp 54	
55	UGC 4881	
56	UGC 1432	
57	Arp 57	
58	UGC 4457	
59	NGC 341	
60	Arp 60	
61	UGC 3104	
62	UGC 6865	
63	NGC 2944	
64	UGC 9503	
65	NGC 90	

66	UGC 10396
67	UGC 892
68	NGC 7757
69	NGC 5579
70	UGC 934
71	NGC 6045
72	NGC 5994, NGC 5996
73	IC 1222
74	UGC 1626
75	NGC 702
76	M90
77	NGC 1097
78	NGC 772

Spiral galaxies with large high surface brightness companions

The Whirlpool Galaxy (M51, Arp 85). This object consists of a larger spiral galaxy interacting with an elliptical galaxy.

Galaxies in this category are almost always clearly interacting sources. The most famous of these objects is the Whirlpool galaxy (M51; Arp 85), which is composed of a spiral galaxy NGC 5194 that is interacting with a smaller elliptical galaxy NGC 5195. The interaction has distorted the shape of both galaxies; the spiral arm pattern has been enhanced in the larger spiral galaxy, and a bridge of stars and gas has formed between the two galaxies. Many of the other galaxies in this category are also connected by bridges.

Arp Number	Common Name	Notes
79	NGC 5490C	
80	NGC 2633	
81	NGC 6621, UGC 11175, NGC 6622	
82	NGC 2535, NGC 2536	

83	NGC 2799, NGC 3800
84	NGC 5394, NGC 5395
85	The Whirlpool Galaxy (M51)
86	NGC 7752, NGC 7753
87	NGC 3808A, NGC 3808B
88	Arp 88
89	NGC 2648
90	NGC 5929, NGC 5930
91	NGC 5953, NGC 5954

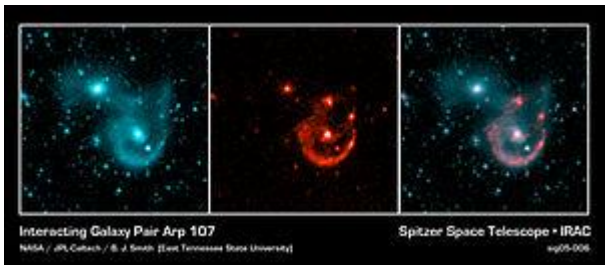
Spiral galaxies with elliptical companions

Like the spiral galaxies with high surface brightness companions, most of these spiral galaxies are clearly interacting systems. Tidal tails and bridges are visible in many of the images.

Arp Number	Common Name	Notes
92	NGC7603	
93	NGC 7284, NGC 7285	
94	NGC 3226, NGC 3227	
95	IC 4461, IC 4462	
96	UGC 3528	
97	UGC 7085A	
98	UGC 1095	
99	NGC 7547, NGC 7549, NGC 7550	Galaxy triplet[8]
100	IC 18, IC 19	
101	UGC 10164, UGC 10169	

Elliptical and elliptical-like galaxies

Elliptical galaxies connected to spiral galaxies



Different wavelength infrared images of Arp 107 (UGC 5984).

These objects are very similar to the spiral galaxies with elliptical companions. All of the galaxies have features such as tidal tails and tidal bridges that have formed through gravitational interaction.

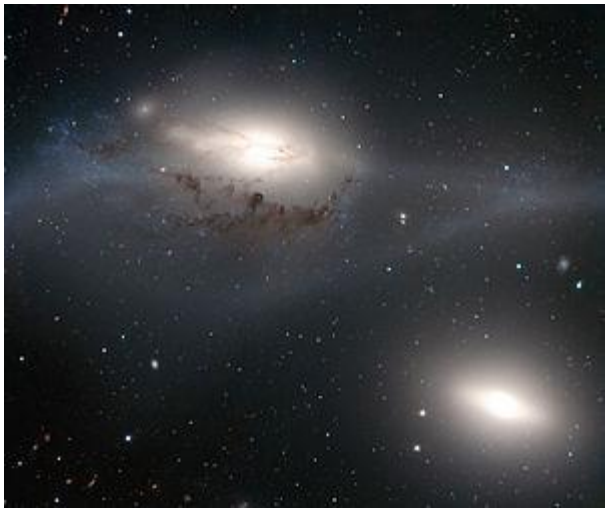
Arp Number	Common Name	Notes
102	Arp 102	
103	UGC 10586	Galaxy triplet[9]
104	NGC 5216, NGC 5218	
105	NGC 3561	
106	NGC 4211	
107	UGC 5984	
108	Arp 108	

Elliptical galaxies repelling spiral arms

Based on the description of these objects, it appears that Arp originally thought that the elliptical galaxies were pushing away spiral arms in companion galaxies. However, the tidal spiral arms may actually look distorted because of the interaction. Some of these "repelled" spiral arms are on the opposite side of the spiral galaxy from the elliptical galaxy. Simulations have shown that such features can be formed through gravitational interactions alone; no repelling forces are needed.

Arp Number	Common Name	Notes
109	UGC 10053	
110	Arp 110	
111	NGC 5421	Galaxy group[10]
112	NGC 7805, NGC 7806	

Elliptical galaxies close to and perturbing spiral galaxies



Galaxy pair NGC 4435 and NGC 4438 (Arp 120)

Messier 60 and NGC 4647 (Arp 116)

This is another category in which the majority of objects are interacting galaxies. As noted in the category name, the spiral galaxies look perturbed. Arp originally described some of the elliptical galaxies as repelling.

Arp Number	Common Name	Notes
113	NGC 70	Part of a group of galaxies[11]
114	NGC 2276, NGC 2300	
115	UGC 6678	Galaxy triplet[12]
116	Messier 60, NGC 4647	
117	IC 982, IC 983	
118	NGC 1141, NGC 1142	
119	Arp 119	
120	NGC 4435, NGC 4438	
121	Arp 121	
122	NGC 6040	
123	NGC 1888, NGC 1889	
124	NGC 6361	
125	UGC 10491	
126	UGC 1449	
127	NGC 191	Actually interacting S0 galaxy and spiral galaxy[12]
128	UGC 827	
129	UGC 5146	
130	IC 5378	
131	Arp 131	
132	Arp 132	

Galaxies with Nearby Fragments

Messier 49, Arp 134

Arp Number	Common Name	Notes
133	NGC541	
134	Messier 49	
135	NGC 1023	
136	NGC 5820	

Material emanating from elliptical galaxies

Arp thought that the elliptical galaxies in this category were ejecting material from their nuclei. Many of the pictures could be interpreted that way. However, these objects are actually a mixture of other phenomena. For example, NGC 2914 (Arp 137) is merely a spiral galaxy with faint spiral arms,[13] and NGC 4015 (Arp 138) is an interacting pair of galaxies where one galaxy is an edge-on spiral galaxy.[14] Some objects, such as NGC 2444 and NGC 2445 (Arp 143), are systems that contain "ring galaxies", which are created when one galaxy (the elliptical galaxies in these examples) passes through the disk of another. This passage causes a gravitational wave in which gas first falls inward and then propagates outward to form the ring structure.[15]

NGC 2936, once a standard spiral galaxy, and NGC 2937, a smaller elliptical.[16]

Arp Number	Common Name	Notes
137	NGC 2914	Spiral galaxy with faint spiral arms[13]
138	NGC 4015	Interacting pair of galaxies[14]
139	Arp 139	Interacting pair of galaxies[17]
140	NGC 274, NGC 275	Interacting pair of galaxies[18]
141	UGC 3730	Ring galaxy system[19]
142	NGC 2936, NGC 2937, UGC 5130	Galaxy triplet[20]
143	NGC 2444, NGC 2445	Ring galaxy system[21]
144	NGC 7828, NGC 7829	Ring galaxy system[22]
145	UGC 1840	Ring galaxy system[23]

Amorphous galaxies

Galaxies in this category are referred to by Arp as galaxies that are neither spiral nor elliptical in shape. Although he does not use the term "amorphous" to describe these galaxies, it is the best description of these galaxies.

Many of these galaxies are either interacting galaxies or galaxies that are the remnants of the merger of two smaller galaxies. The interaction process will produce various tidal features, such as tidal tails and tidal bridges, that may last well after the progenitor galaxies' disks and nuclei have merged. Although the tidal tails are described as several different visual phenomena ("counter-tails", "filaments", "loops"), they are all manifestations of the same phenomena.

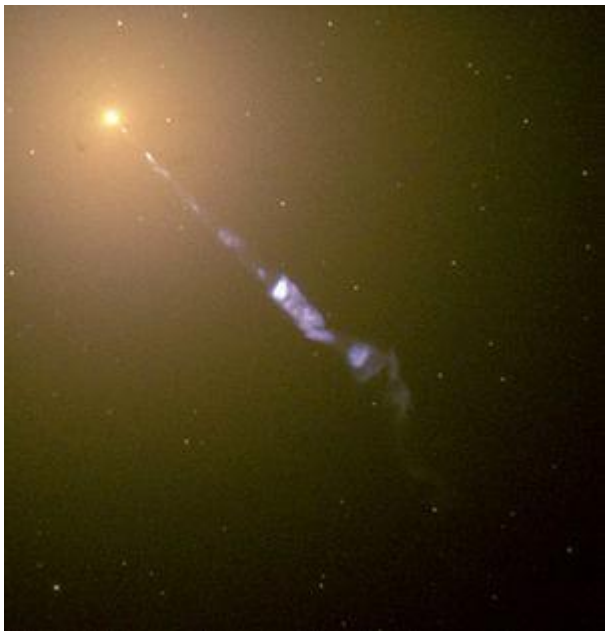
Galaxies with associated rings

Interacting galaxy pair Arp 148 (Mayall's Object)

As noted above, these ring galaxies may have formed when a companion galaxy passed through the ring galaxy. The interaction would produce a wave effect that would first draw matter into the center and then cause it to propagate outward in a ring.[15]

Arp Number	Common Name	Notes
146	Arp 146	
147	IC 298	
148	Arp 148	

Galaxies with jets



Giant elliptical galaxy Messier 87 with its relativistic jet (Arp 152)

These are galaxies that appear to be ejecting material outwards from their nuclei. The "jets" themselves look similar to water spraying out of a hose. In the case of IC 803 (Arp 149) and NGC 7609 (Arp 150), the jets are simply part of the amorphous structure produced by the interacting galaxies. In Arp 151 and Messier 87 (Arp 152), however, the jets are ionized gas that has been ejected from the environment around supermassive black holes in the galaxies' active galactic nuclei.[24][25] These jets, sometimes called relativistic jets or radio jets, are powerful sources of synchrotron radiation, especially at radio wavelengths.

Arp Number	Common Name	Notes
149	IC 803	Interacting galaxies[26]
150	NGC 7609	Interacting galaxies[27]
151	Arp 151	Seyfert galaxy (contains an active galactic nucleus)[24]
152	Messier 87	Seyfert galaxy (contains an active galactic nucleus)[25]

Disturbed galaxies with interior absorption

Merging galaxy pair named NGC 520 (Arp 157).

Giant elliptical galaxy NGC 1316.

Galaxies in this category feature dark dust lanes that obscure part of the disk of the galaxy. All of these galaxies are the products of two galaxies merging. NGC 520 (Arp 157) is one of the best examples of an intermediate-stage merger, where the two progenitor galaxies' disks have coalesced together but the nuclei have not. Centaurus A (Arp 153) and NGC 1316 (Arp 154) are both effectively elliptical galaxies with unusual dust lanes; their kinematics and structure indicate that they have undergone merging events recently. NGC 4747 (Arp 159) may be nothing more than an edge-on spiral galaxy with a significantly dark dust lanes.[28]

Arp Number	Common Name	Notes
153	Centaurus A	Notable radio galaxy; contains an active galactic nucleus)[29]
154	NGC 1316	Notable radio galaxy; contains an active galactic nucleus)[29]
155	NGC 3656	
156	UGC 5184	
157	NGC 520	Notable intermediate-stage merger
158	NGC 523	
159	NGC 4747	Spiral galaxy with dark dust lanes[28]
160	NGC 4194	Also known as the Medusa Galaxy

Galaxies with diffuse filaments

The filaments in these objects may represent tidal tails from galaxy interactions. Many of the galaxies are the remnants of the mergers of two spiral galaxies to form a single elliptical galaxy. However, NGC 3414 (Arp 162) appears to be merely an unusual S0 galaxy with a very small disk relative to its bulge size.[3] NGC 4670 (Arp 163) is a blue compact dwarf galaxy with extremely strong star formation activity;[30] it is clearly too small to be the merger remnant of

two spiral galaxies like the other merger remnants in this sample, although it may have been involved in a much smaller interaction.

Arp Number	Common Name	Notes
161	UGC 6665	
162	NGC 3414	S0 galaxy[3]
163	NGC 4670	Blue compact dwarf galaxy[30]
164	NGC 455	
165	NGC 2418	
166	NGC 750, NGC 751	

Galaxies with diffuse counter-tails

All of these objects are galaxies involved in gravitational interactions. These counter-tails are tidal features caused by the gravitational interactions between two galaxies, just like similar features described in the Arp catalog. Messier 32 (Arp 168), a dwarf galaxy interacting with the Andromeda Galaxy,[3] is included in this category (although the "diffuse counter-tail" is very difficult to see in Arp's photograph).

Arp Number	Common Name	Notes
167	NGC 2672, NGC 2673	
168	Messier 32	Dwarf galaxy interacting with Andromeda Galaxy[3]
169	NGC 7236, NGC 7237, NGC 7237C	Galaxy triplet[31]
170	NGC 7578	
171	NGC 5718, IC 1042	
172	IC 1178, IC 1181	

Galaxies with narrow counter-tails

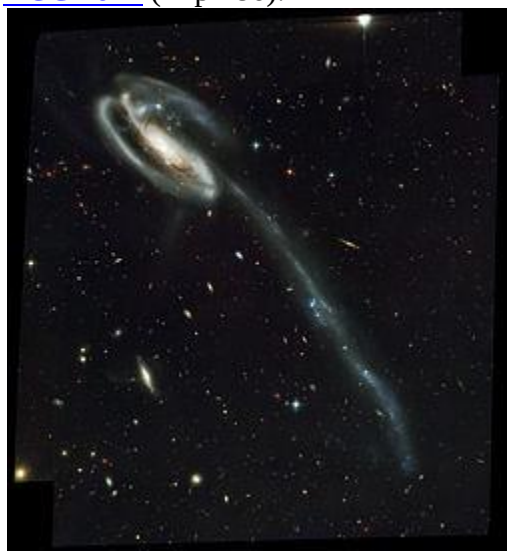
This is another category containing galaxies with tidal tails produced by gravitational interactions. These tidal tails are narrower and better defined than the tidal tails in objects 167-172.

Arp Number	Common Name	Notes
173	UGC 9561	
174	NGC 3068	
175	IC 3481, IC 3481A, IC 3483	Galaxy triplet[32]
176	NGC 4933	Galaxy triplet[33]
177	Arp 177	

178	NGC 5613, NGC 5614, NGC 5615	Galaxy triplet[34]

Galaxies with narrow filaments

NGC 1614 (Arp 186).



The Tadpole Galaxy (UGC 10214; Arp 188). The "narrow filament", which appears to be tidal feature caused by a gravitational interaction, can be seen extending across this image.

This category contains a mixture of different types of objects. Like the galaxies with diffuse filaments or galaxies with counter-tails, some of the galaxies in this category have been involved in interactions, and the filaments are tidal features created by those interactions. Other sources, however, are simply individual spiral galaxies with faint spiral arms that are described as "filaments" by Arp.

Arp Number	Common Name	Notes
179	Arp 179	
180	Arp 180	Interacting galaxy pair[35]

181	NGC 3212, NGC 3215	Interacting galaxy pair[36]
182	NGC 7674, NGC 7674A	Interacting galaxy pair[37]
183	UGC 8560	Spiral galaxy[38]
184	NGC 1961	Spiral galaxy[39]
185	NGC 6217	Spiral galaxy[40]
186	NGC 1614	Spiral galaxy involved in recent interaction[41]
187	Arp 187	
188	Tadpole Galaxy	Galaxy involved in recent interaction
189	NGC 4651	Tidal star streams[42]
190	UGC 2320	Interacting galaxy pair[43]
191	UGC 6175	Interacting galaxy pair[44]
192	NGC 3303	Interacting galaxy pair[45]
193	IC 883	Merger remnant

Galaxies with material ejected from nuclei

Arp 194. The third galaxy at the bottom of the image is actually a further object, not part of the system.

The ejecta in many of these objects appear to be tidal features created by gravitational interactions. In some cases (such as for NGC 5544 and NGC 5545 in Arp 199), the "ejecta" are clearly a spiral galaxy viewed edge-on that happens to line up with another galaxy's nucleus.

Almost all of the objects in this category are interacting or have recently undergone interactions. NGC 3712 (Arp 203) is an exception; it is merely a low surface brightness spiral galaxy.[46]

Arp	Common Name	Notes

Number		
194	UGC 6945	Interacting galaxy pair[47]
195	UGC 4653	Interacting galaxy triplet[48]
196	Arp 196	Interacting galaxy pair[49]
197	UGC 6503, IC 701	Interacting galaxy pair[50]
198	UGC 6073	Interacting galaxy pair[51]
199	NGC 5544, NGC 5545	Interacting galaxy pair[52]
200	NGC 1134	Spiral galaxy interacting with low surface brightness galaxy[53]
201	UGC 224	Interacting galaxy pair[54]
202	NGC 2719, NGC 2719A	Interacting galaxy pair[55]
203	NGC 3712	Low surface brightness spiral galaxy[46]
204	UGC 8454	Interacting galaxy pair[56]
205	NGC 3448	Merger remnant[57]
206	UGC 5983, NGC 3432	Interacting galaxy pair[58]
207	UGC 5050	Spiral galaxy interacting with dwarf galaxy[59]
208	Arp 208	Interacting galaxy pair[60]

Galaxies with irregularities, absorption, and resolution

Starburst activity in nearby dwarf galaxy NGC 1569 (Arp 210).

Galaxies in this category have either irregular structures (irregularities), notable dust lanes (absorption), or a grainy appearance (resolution). This category contains a mix of interacting galaxies distorted by tidal interactions, nearby dwarf irregular galaxies, and spiral galaxies with unusual large amounts of gas.

Arp Number	Common Name	Notes
209	NGC 6052	Interacting galaxy pair[61]
210	NGC 1569	Dwarf galaxy[62]
211	UGCA 290	Interacting dwarf galaxies[63]

212	NGC 7625	Peculiar spiral galaxy[64]
213	IC 356	Peculiar spiral galaxy[65]
214	NGC 3718	Peculiar spiral galaxy[66]

Galaxies with adjacent loops

Nearby starburst spiral galaxy NGC 3310 (Arp 217)

These adjacent loops are another manifestation of the structures formed by gravitational interactions between galaxies. Some of these sources consist of galaxies that have nearly completed the merger process; the "adjacent loops" are merely the remnants of the interaction. Among the objects in this category is Arp 220, one of the best-studied ultraluminous infrared galaxies in the sky.

Arp Number	Common Name	Notes
215	NGC 2782	Peculiar spiral galaxy[3]
216	NGC 7679, NGC 7682	Interacting galaxy pair[67]
217	NGC 3310	Notable nearby starburst;[68] merger remnant[3]
218	Arp 218	Interacting galaxy pair[69]
219	UGC 2812	Galaxy in interaction[70]
220	IC 4553	Merger remnant; notable ultraluminous infrared galaxy

Galaxies with amorphous spiral arms

Spiral galaxy NGC 7252 (Arp 226)

Many of these galaxies are merger remnants. The "amorphous spiral arms" are the tidal debris that remains after the collision.

Arp Number	Common Name	Notes
221	Arp 221	Interacting galaxy triplet[71]
222	NGC 7727	Merger remnant[3]
223	NGC 7585	Recent inequal-mass merger[3]
224	NGC 3921	Merger remnant
225	NGC 2655	Recent inequal-mass merger
226	The Atoms for Peace Galaxy (NGC 7252)	Merger remnant[3]

Galaxies with concentric rings

NGC 474, Arp 227

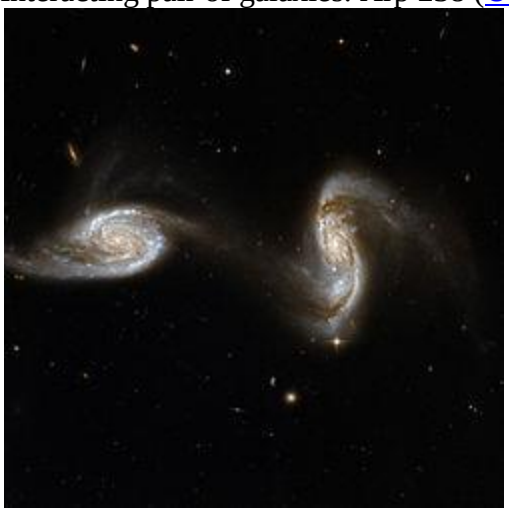
These are galaxies with shell-like structures. Some shell structures have been identified as the results of recent mergers.[*citation needed*] In other cases, however, the shell structure may represent the outer disk of an S0 galaxy. In some complicated cases, the galaxy with the rings or shells is

an S0 galaxy interacting with another galaxy; the origins of the shells in such systems can be difficult to determine.

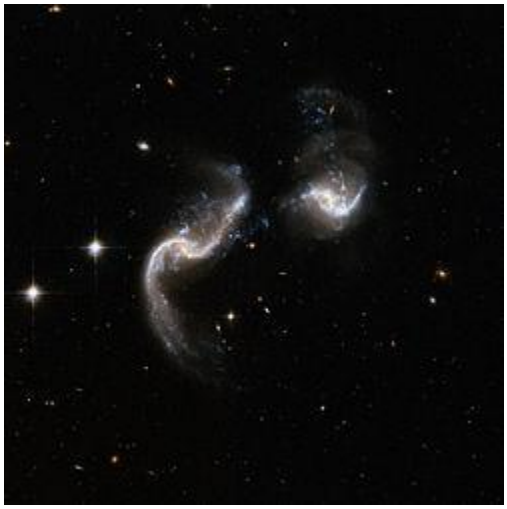
Arp Number	Common Name	Notes
227	NGC 470, NGC 474	Interacting galaxy pair with one S0 galaxy[72]
228	IC 162	S0 galaxy[73]
229	NGC 507, NGC 508	Interacting galaxy pair including one S0 galaxy and one elliptical galaxy[74]
230	IC 51	Peculiar S0 galaxy;[75] possible merger remnant
231	IC 1575	
232	NGC 2911	Peculiar S0 galaxy[76]

Galaxies with the appearance of fission

Interacting pair of galaxies: Arp 238 (UGC 8335).



NGC 5257 and NGC 5258 (Arp 240), interacting pair of spiral galaxies.



Arp 256, spiral galaxy pair in the early stages of colliding and merging.

Although the description of the objects in this category implies that the galaxies are separating apart, most of these galaxies are merging. Many of the objects have very pronounced tidal tails and bridges that have formed as a consequence of the interaction. Most objects are in the early stages of the merging process, where the galaxies still appear to have distinct nuclei and distinct (albeit distorted) disks. Among the most notable galaxies in this category are the Antennae Galaxies (NGC 4038 and NGC 4039, Arp 244) and the Mice Galaxies (NGC 4676, Arp 242).

However, not all of these objects are interacting galaxies. A few of these galaxies are simply nearby dwarf galaxies with irregular structure.

Arp Number	Common Name	Notes
233	UGC 5720	Dwarf galaxy[77]
234	NGC 3738	Dwarf galaxy[78]
235	NGC 14	Dwarf galaxy[79]
236	IC 1623	Interacting galaxy pair[80]
237	UGC 5044	Interacting galaxy pair[81]
238	UGC 8335	Interacting galaxy pair[82]
239	NGC 5278, NGC 5279	Interacting galaxy pair[83]
240	NGC 5257, NGC 5258	Interacting galaxy pair[84]
241	UGC 9425	Interacting galaxy pair[85]
242	Mice Galaxies (NGC 4676)	Interacting galaxy pair[86]
243	NGC 2623	Interacting galaxy triplet[87]
244	Antennae Galaxies (NGC 4038, NGC 4039)	Interacting galaxy pair[88]
245	NGC 2992, NGC 2993	Interacting galaxy pair[89]
246	NGC 7837, NGC 7838	Interacting galaxy pair[90]
247	UGC 4383	Interacting galaxy pair[91]
248	Arp 248	Interacting galaxy triplet[92]

249	UGC 12891	Interacting galaxy pair[93]
250	Arp 250	
251	Arp 251	Interacting galaxy triplet[94]
252	Arp 252	Interacting galaxy pair[95]
253	UGCA 173, UGCA 174	Interacting galaxy pair[96]
254	NGC 5917	Peculiar spiral galaxy[97]
255	UGC 5304	Interacting galaxy pair[98]
256	Arp 256	Interacting galaxy pair[99]

Galaxies with irregular clumps

Holmberg II/UGC 4305, dwarf galaxy (Arp 268)

Interacting galaxy pair Arp 261.

These are objects that appear to be a series of irregular clumps with no coherent structure. Many of these objects are simply nearby dwarf galaxies. Some of these objects are interacting galaxies, while others are small groups of galaxies. In both cases, many of the constituent galaxies are irregular galaxies. The superposition of two or more such irregular galaxies can easily look like a single larger irregular galaxy, which is why the **Atlas of Peculiar Galaxies** (and other catalogs) often classify these pairs and groups as single objects.

Arp Number	Common Name	Notes
257	UGC 4638	Interacting galaxy pair[100]
258	UGC 2140	Galaxy group[101]
259	NGC 1741	Galaxy group[102]
260	UGC 7230	Interacting galaxy pair[103]
261	Arp 261	Galaxy group[104]
262	UGC 12856	Interacting galaxy pair[105]
263	NGC 3239	Dwarf galaxy[106]
264	NGC 3104	Dwarf galaxy[107]
265	IC 3862	Interacting galaxy pair[108]
266	NGC 4861	Dwarf galaxy[109]
267	UGC 5746	Dwarf galaxy[110]
268	UGC 4305, Holmberg II	Dwarf galaxy[111]

Double and multiple galaxies

Arp originally referred to these galaxies as "double galaxies", but many of these sources are more than two galaxies. Some of the objects consist of interacting galaxies, whereas other sources are actually groups of galaxies. The difference is that interacting galaxies will be distorted, whereas galaxies in groups are simply gravitationally bound to each other but not necessarily close enough to each other to induce major structural changes.

Galaxies with connected arms

Arp 272: NGC 6050 and IC 1179, interacting spiral galaxies.

All of these galaxies are interacting pairs of galaxies except for NGC 5679 (Arp 274), which may be an interacting galaxy triplet.[112] The connected arms described here are tidal bridge features that form between interacting galaxies. These bridges form early during galaxy interactions.

Arp Number	Common Name	Notes
269	NGC 4485, NGC 4490	Interacting galaxy pair[113]
270	NGC 3395, NGC 3396	Interacting galaxy pair[114]
271	NGC 5426, NGC 5427	Interacting galaxy pair[115]
272	NGC 6050, IC 1179	Interacting galaxy pair[116]
273	UGC 1810, UGC 1813	Interacting galaxy pair[117]
274	NGC 5679	Interacting galaxy triplet[112]

Interacting galaxies

'The Bird' is composed of two massive spiral galaxies and a third irregular galaxy.

Unlike many of the objects listed in the *amorphous galaxies* section, the interacting galaxies that comprise these objects are still distinguishable from each other.

Arp Number	Common Name	Notes
275	NGC 2881	Interacting galaxy pair[118]
276	NGC 935, IC 1801	Interacting galaxy pair[119]
277	NGC 4809, NGC 4810	Interacting galaxy pair[120]
278	NGC 7253	Interacting galaxy pair[121]
279	NGC 1253, NGC 1253A	Interacting galaxy pair[122]
280	NGC 3769, NGC 3769A	Interacting galaxy pair[123]

Galaxies with infall and attraction

Edge-on spiral galaxy NGC 4631 and dwarf elliptical NGC 4627 (below) comprise the Arp 281 pair

This category contains an odd mixture of objects. Two of the objects are edge-on disk galaxies with smaller companion galaxies nearby. Two of the objects are connected by tidal bridges. The last two objects may simply be interacting with each other over long distance.

Arp Number	Common Name	Notes
281	NGC 4627, NGC 4631	Spiral galaxy with companion dwarf elliptical galaxy[124]
282	NGC 169, NGC 169A	Spiral galaxy with smaller companion galaxy[125]
283	NGC 2798, NGC 2799	Interacting galaxy pair[126]
284	NGC 7714, NGC 7715	Interacting galaxy pair[127]
285	NGC 2854, NGC 2856	Galaxy pair[128]
286	NGC 5560, NGC 5566, NGC 5569	Interacting galaxy triplet[3][129]

Galaxies with wind effects

Although included in the double galaxies category, many of these objects are individual galaxies. The "wind effects" refer to the appearance, not the actual detection of high-velocity gas (such as is found in M82). In some cases, the appearance may be the result of interaction. In other cases, particularly NGC 3981 (Arp 289), the faint, extended emission may be related to the intrinsic nature of the galaxy itself and not interactions with other objects.[3]

Arp Number	Common Name	Notes
287	NGC 2735, NGC 2735A	Galaxy pair[130]
288	NGC 5221, NGC 5222	Galaxy triplet[131]
289	NGC 3981	Peculiar spiral galaxy[3][132]
290	IC 195, IC 196	Interacting galaxy pair[133]
291	UGC 5832	Irregular galaxy[134]
292	IC 575	Peculiar spiral galaxy[135]
293	NGC 6285, NGC 6286	Interacting galaxy pair[136]

Double or multiple galaxies with long filaments

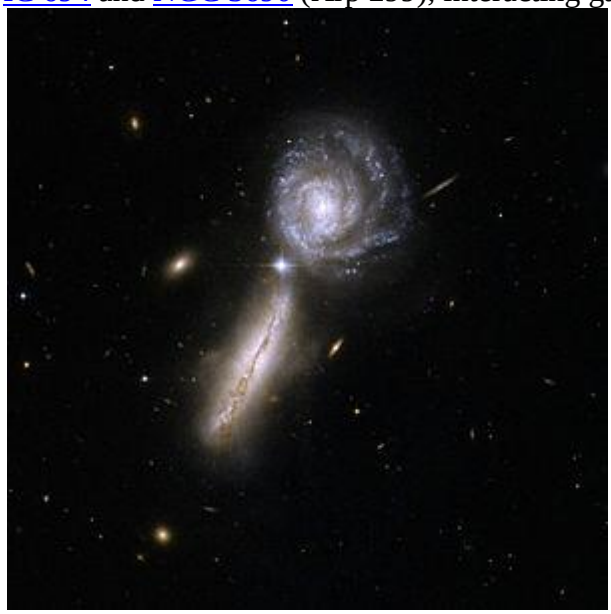
Arp 297: spiral (NGC 5754) /irregular galaxy (NGC 5752) pair

The long filaments in these systems are probably tidal tails or bridges that have been produced as the result of the gravitational interaction between the galaxies.

Arp Number	Common Name	Notes
294	NGC 3786, NGC 3788	Interacting galaxy pair[137]
295	Arp 295	Interacting galaxy pair[138]
296	Arp 296	
297	Arp 297	Interacting galaxies within a galaxy group[139]

Unclassified objects

IC 694 and NGC 3690 (Arp 299), interacting galaxy pair



UGC 9618 (Arp 302), a pair of a face-on and an edge-on spiral galaxy

Arp did not give a subclassification for objects 298-310 in his atlas. These objects are mostly interacting galaxy pairs.

Arp Number	Common Name	Description
298	NGC 7469, IC 5283	Galaxy pair[140]
299	Arp 299	Galaxy triplet[141]
300	Arp 300	Galaxy group[142]
301	UGC 6204, UGC 6207	Galaxy pair[143]

302	UGC 9618	Galaxy pair[144]
303	IC 563, IC 564	Galaxy pair[145]
304	NGC 1241, NGC 1242	Galaxy pair[146]
305	NGC 4016, NGC 4017	Galaxy pair[147]
306	UGC 1102	Galaxy group with two galaxy pairs[148]
307	NGC 2872, NGC 2874	Galaxy pair[149]
308	NGC 545, NGC 547	Galaxy pair[150]
309	NGC 942, NGC 943	Galaxy pair[151]
310	IC 1259	Galaxy pair[152]

Groups of galaxies

Arp Number	Common Name	Description
311	IC 1258 and Companions	
312	MCG +08-31-004	
313	NGC 3994 + NGC 3995	
314	MCG -03-58-009 + MCG -03-58-010 + MCG -03-58-011	
315	NGC 2830 + NGC 2831 + NGC 2832	
316	NGC 3193	
317	Leo Triplet	
318	NGC 833 and companions	
319	Stephan's Quintet	
320	Copeland's Septet	
321	Hickson 40 A-E	

Chains of galaxies

Arp Number	Common Name	Description
322	UGC 6527	
323	Hickson 98 A-D	
324	UGC 10143	
325	ESO601-G018A+B and MCG -04-52-014	
326	UGC 8610	
327	NGC 1875; Hickson 34 A-D	
328	UGC 9532; Hickson 72	
329	UGC 6514	
330	I Zw 167; MCG +09-27-094	
331	NGC 379 and companions (Pisces Cloud)	
332	NGC 1228	

Miscellaneous

Hubble Telescope image of Messier 82

Arp Number	Common Name	Description
333	NGC 1024	
334	UGC 8498	
335	NGC 3509	
336	NGC 2685	
337	Messier 82	
338	PGC 3094767	

Brightest Arp galaxies for amateur astronomers

Maynard Pittendreigh, an amateur astronomer and occasional writer, has compiled a list of the brightest Arp Galaxies that are most easily viewed by typical amateur astronomers. The galaxies on the list can be observed visually and do not require special photographic or imaging equipment. These include:

- Arp 26, also known as M101
- Arp 37, also known as M77
- Arp 76, also known as M90
- Arp 77
- Arp 85, also known as M51
- Arp 116, also known as M60
- Arp 120
- Arp 152, also known as M87
- Arp 153
- Arp 168, also known as M32
- Arp 244
- Arp 269
- Arp 270
- Arp 271
- Arp 281
- Arp 286
- Arp 317, also known as M65

- Arp 313
- Arp 337, also known as M82

See also

Space portal

- Index Catalogue (IC)
- Messier object (M)
- New General Catalogue (NGC)
- Uppsala General Catalogue (UGC)

Further reading

- J. Kanipe, D. Webb *The Arp Atlas of Peculiar Galaxies, A Chronicle and Observer's Guide*, Willmann-Bell Inc. (2006) ISBN 978-0-943396-76-7

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External links

Wikimedia Commons has media related to ***Arp galaxies***.

- Amateur observations of the galaxies
- Earthlings - Astronomy web site Paul and Liz Downing
- Grasslands Observatory Arp Galaxies
- Dick Miller's images of all 338 Arps
- Information for observing Arp Peculiar Galaxies
- Hubble Images Peculiar Galaxy Pair Arp 87
- NASA/IPAC Extragalactic Database Electronic Copy of the '*Atlas of Peculiar Galaxies*

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Copied to note critics for posterity as they will try to change this with time

Halton Arp

From Wikipedia, the free encyclopedia

Halton Arp

Halton Arp in London, October 2000

Born	March 21, 1927 New York City, United States
Died	December 28, 2013 (aged 86) Munich, Germany
Residence	Germany
Nationality	American
Fields	Astronomy
Institutions	Palomar Observatory Max Planck Institute for Astrophysics
Alma mater	California Institute of Technology
Doctoral advisor	Walter Baade
Known for	Intrinsic redshift Atlas of Peculiar Galaxies
Notable awards	Newcomb Cleveland Prize (1960) Helen B. Warner Prize for Astronomy (1960)

Halton Christian "Chip" Arp (March 21, 1927 – December 28, 2013) was an American astronomer. He was known for his 1966 *Atlas of Peculiar Galaxies*, which (it was later realized) catalogues many examples of interacting and merging galaxies. Arp was also known as a critic of the Big Bang theory and for advocating a non-standard cosmology incorporating intrinsic redshift.

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Biography

Halton Arp (right) and his grandsons, 2008

Arp was born on March 21, 1927, in New York City. He was married three times, has four daughters and five grandchildren.[1][2] His bachelor's degree was awarded by Harvard (1949), and his PhD by Caltech (1953). Afterward he became a Fellow of the Carnegie Institution of Washington in 1953, performing research at the Mount Wilson Observatory and Palomar Observatory. Arp became a Research Assistant at Indiana University in 1955, and then in 1957 became a staff member at Palomar Observatory, where he worked for 29 years. In 1983 he joined the staff of the Max Planck Institute for Astrophysics in Germany. He died in Munich, Germany on December 28, 2013.[2][3]

The Atlas of Peculiar Galaxies

Arp compiled a catalog of unusual galaxies titled *Atlas of Peculiar Galaxies*, which was first published in 1966.[4] Arp realized that astronomers understood little about how galaxies change over time, which led him to work on this project. This atlas was intended to provide images that would give astronomers data from which they could study the evolution of galaxies. Arp later used the atlas as evidence in his debate on quasi-stellar objects (QSOs).

Based on its citation by other astronomers, Arp's atlas is recognized now as an excellent compilation of interacting and merging galaxies. Many objects in the atlas are primarily referred to by their Arp number. Many of these objects (particularly Arp 220) are also used as spectral templates for studying high-redshift galaxies.

Quasars and redshifts

Characterizing quasars

During the 1950s bright radio sources had been discovered that did not appear to have an optical counterpart. In 1960 one of these sources, 3C 48, was found to be associated with what appeared to be a small blue star. When the spectrum of the star was measured, it contained unidentifiable spectral lines that defied all attempts at explanation; John Gatenby Bolton's suggestion that these were highly redshifted sources was not widely accepted.

In 1963 Maarten Schmidt found a visible companion to 3C 273. Using the Hale telescope, Schmidt found the same odd spectra, but was able to demonstrate that it could be explained as the spectrum of hydrogen, shifted by a very large 15.8% If this was due to the physical motion of the "star", it would represent a speed of 47,000 km/s, far beyond the speed of any known star and defying an obvious explanation. Nor would this explain the huge radio emissions that had led to its original detection.

Schmidt noted that redshift is also associated with the expansion of the universe, as codified in Hubble's law. If the measured redshift was due to expansion, then the object in question would have to be very far away. In that case, it would have to have an extraordinarily high luminosity, equally beyond any object seen to date. This extreme luminosity would also explain the large radio signal. Schmidt concluded quasars are very distant, very luminous objects.[5]

Schmidt's explanation for the high redshift was not universally accepted at the time. Another explanation that was offered was that it was gravitational redshift that was being measured; this would require a massive object that would also explain the high luminosities. A star large enough to produce the measured redshift would be well beyond the Hayashi limit. Several other mechanisms were proposed as well, each with their own problems.

Arp's suggestion

In 1966, Arp published the *Atlas of Peculiar Galaxies*, which contained photographs of 338 nearby galaxies that did not fall into any of the classic categories of galaxy shapes. His goal was to produce a selection that modellers could use in order to test theories of galactic formation. By testing against the collection, one could quickly see how well a particular theory stood up.

One group of these, numbers 1 through 101, were otherwise conventional galaxies that appeared to have small companion objects of unknown origin. In 1967 Arp noted that several of these objects appeared on the list of quasars. In some photographs a quasar is in the foreground of known galaxies, and in others there appeared to be matter bridging the two objects, implying they are very close in space. If they are, and the redshifts were due to Hubble expansion, then both objects should have similar redshifts. The galaxies had much smaller redshifts than the quasars. Arp argued that the redshift was not due to Hubble expansion or physical movement of the objects, but must have a non-cosmological or "intrinsic" origin.

Arp also noted that quasars were not evenly spread over the sky, but tended to be more commonly found in positions of small angular separation from certain galaxies. This being the case, they might be in some way related to the galaxies. Arp's hypothesis is that quasars are local objects ejected from the core of active galactic nuclei (AGN). Nearby galaxies with both strong radio emission and peculiar morphologies, particularly M87 and Centaurus A, appeared to support Arp's hypothesis.[6]

In his books, Arp has provided his reasons for believing that the Big Bang theory is wrong, citing his research into quasi-stellar objects (QSOs). Instead, Arp supported the redshift quantization theory as an explanation of the redshifts of galaxies.[7]

Critics

Arp originally proposed his theories in the 1960s; telescopes and astronomical instrumentation have advanced greatly since then: the Hubble Space Telescope was launched, multiple 8-10 meter telescopes (such as those at Keck Observatory and the Very Large Telescope) have become operational, and detectors such as CCDs are now more widely employed. These new telescopes and new instrumentation have been used to examine QSOs further. QSOs are now generally accepted to be very distant galaxies with high redshifts. Many imaging surveys, most notably the Hubble Deep Field, have found many high-redshift objects that are not QSOs but that appear to be normal galaxies like those found nearby.[8] The spectra of the high-redshift galaxies, as seen from X-ray to radio wavelengths, match the spectra of nearby galaxies (particularly galaxies with high levels of star formation activity but also galaxies with normal or extinguished star formation activity) when corrected for redshift effects.[9][10][11] As more recent experiments have expanded the amount of collected data by orders of magnitude, it has become increasingly simple to test Arp's postulates directly. A recent study stated that:

> "... the publicly available data from the Sloan Digital Sky Survey and 2dF QSO redshift survey to test the hypothesis that QSOs are ejected from active galaxies with periodic noncosmological redshifts. For two different intrinsic redshift models, [...] and find there is no evidence for a periodicity at the predicted frequency in log(1+z), or at any other frequency."[12]

Arp did not waver from his stand against the Big Bang, and until shortly before his death continued to publish articles[13][14] stating his contrary view in both popular and scientific literature, frequently collaborating with Geoffrey Burbidge (until his death in 2010) and Margaret Burbidge.[15]

Honors and awards

In 1960, Arp was awarded the Helen B. Warner Prize for Astronomy by the American Astronomical Society, a prize "normally awarded annually for a significant contribution to observational or theoretical astronomy during the five years preceding the award."[16]

In the same year, Arp was awarded the Newcomb Cleveland Prize for his address, "The Stellar Content of Galaxies", read before a joint session of the American Astronomical Society and AAAS Section D.[17]

In 1984, he was awarded the Alexander von Humboldt Senior Scientist Award.[18]

See also

- **Main** : Quasars, Redshifts and Controversies (ISBN 0-521-36314-4)
- **List of astronomical topics** : Quasar
- **Cosmology** : Non-standard cosmology, Intrinsic redshifts, Redshift quantization, Le Sage's theory of gravitation, Big Bang
- **Other** : Helen B. Warner Prize for Astronomy

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Further reading

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- Halton Arp, *Seeing Red*, Aperion (August 1998) ISBN 0-9683689-0-5
- Halton Arp, *Catalogue of Discordant Redshift Associations*, Aperion (September 1, 2003) ISBN 0-9683689-9-9
- G. Burbidge, E.M. Burbidge, H.C. Arp, W.M. Napier: *Ultraluminous X-ray Sources, High Redshift QSOs and Active Galaxies.* Preprint
- J. Kanipe, D. Webb *The Arp Atlas of Peculiar Galaxies, A Chronicle and Observer's Guide*, Willmann-Bell Inc. (2006) ISBN 978-0-943396-76-7

External links

- Halton Arp's Website
- Apeiron, journal web site (Arp is editorial board member)
- Publications by Halton C. Arp at the Scientific Commons repository
- *Atlas of Peculiar Galaxies*
- Arp's Catalog of Peculiar Galaxies website
- Detailed review of *Seeing Red* by Tom Van Flandern
- Electric Politics interview with Halton C. Arp (podcast)
- Astraea Magazine interview with Halton C. Arp (podcast)
- Preface to "The Arp Atlas of Peculiar Galaxies"
- Author's Notes to "The Arp Atlas of Peculiar Galaxies"
- Halton Arp directory page at the IAU
- Oral History interview transcript with Halton Arp 29 July 1975, American Institute of Physics, Niels Bohr Library and Archives