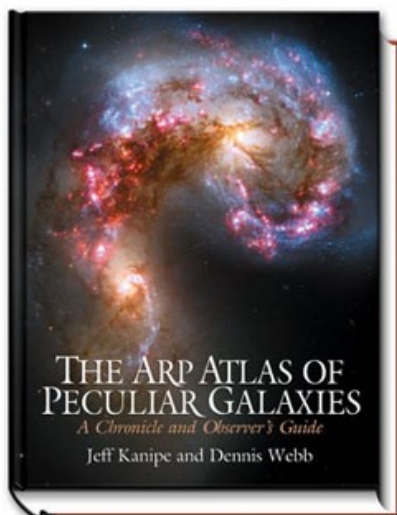


## ARP ATLAS OF PECULIAR GALAXIES, A Chronicle and Observer's Guide

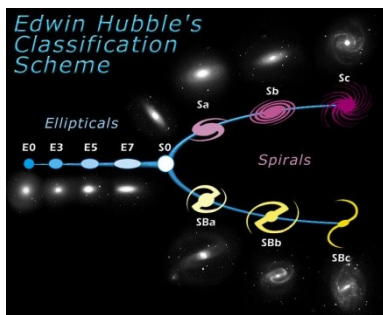


### The Arp Atlas<sup>1</sup>

by Jeff Kanipe and Dennis Webb, 8.5x11, 400 pages, \$39.95 from Willmann-Bell

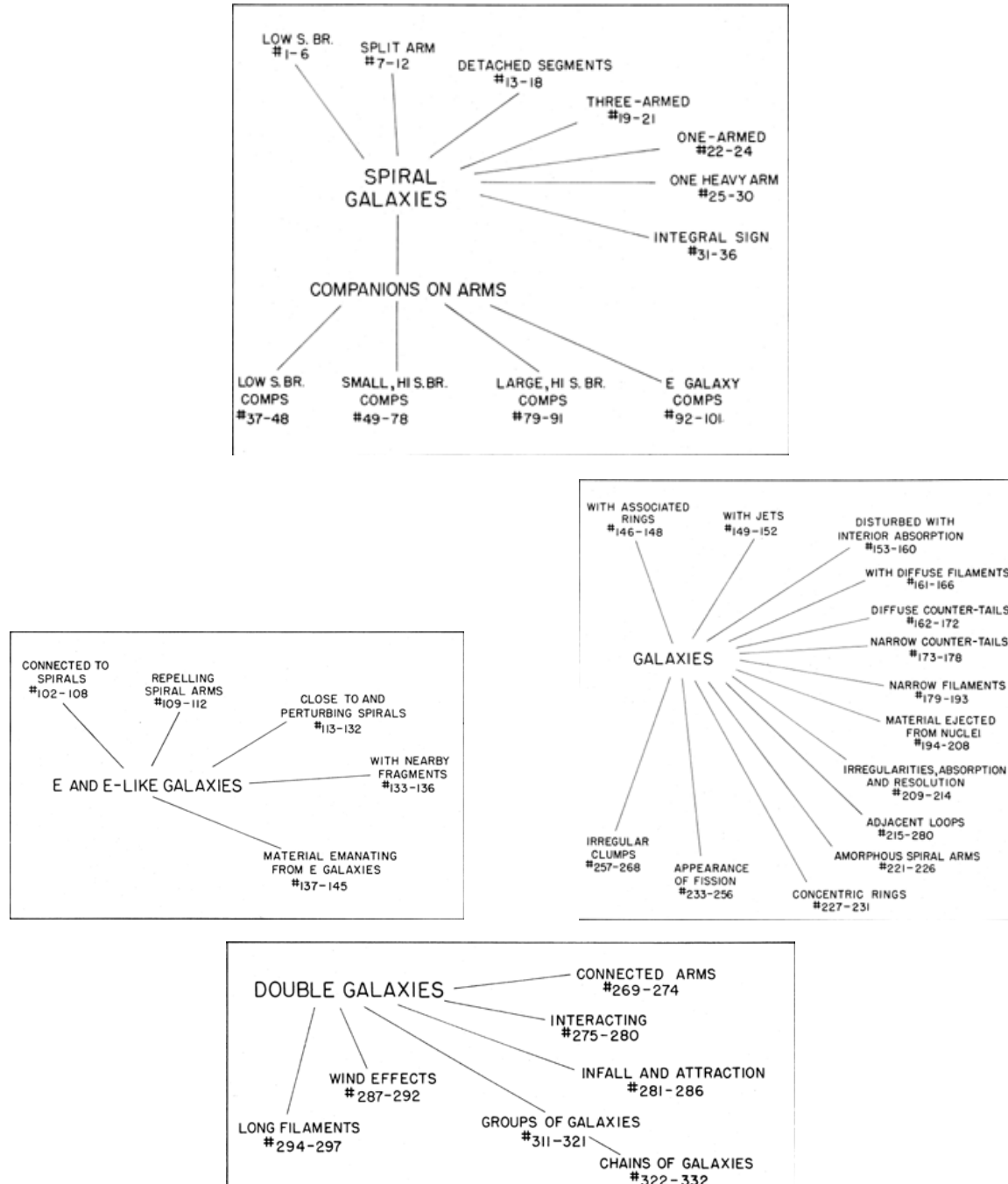
**The Arp Atlas of Peculiar Galaxies, a Chronicle and Observer's Guide** is unlike any atlas you may have looked at before. Yes, it has charts (27 including the key), but it features a collection of unusual galaxies the likes of which most people have never seen. Most of us have seen M51, the Whirlpool Galaxy. And in fact, there are 10 other Messier objects in the Atlas. But M51 is only the tip of the iceberg, as it is a deformed galaxy with a companion on an arm. In the Atlas there are galaxies with "Counter-Tails, Rings, Jets, 'Wind' Effects, Plumes, Galaxy Chains, Single- and Multi- Armed Galaxies and other oddities".<sup>1</sup>

**DISCOVERY OF 'PECULIAR GALAXIES':** In the period of 1949-1958, the Palomar Observatory Sky Survey (POSS-1), sponsored by the National Geographic Institute, was conducted for the northern sky. The area covered was from the celestial north-pole to  $-27^\circ$  declination and all right ascensions to a sensitivity of +22 magnitude. The field of view was  $6^\circ \times 6^\circ$ . About 950 plate-pairs were used using blue and red-sensitive Kodak material. This survey was done with the 48" Oschin Schmidt telescope on Palomar Mountain. After publication, Dr. Halton C. Arp began a study of some peculiar galaxies discovered by other astronomers, namely Fritz Zwicky (who conducted the survey) and Vorontsov-Velyaminov. After culling a number of candidates from NGC-POSS-I survey, Dr. Arp sampled high-resolution photographs with the Palomar 200-inch telescope. In reviewing the new images, he realized a new system of classification was needed as none of his selections fit the classic Hubble "Tuning Fork" Classification Scheme.



## Hubble's Tuning Fork <sup>2</sup>

**ARP'S CLASSIFICATIONS:** As a result of his studies, Dr. Arp developed 5 categories with 39 sub-categories as shown on page 10 of the new Atlas. The classifications were based upon similar characteristics found in the samples.



The above figures are from the Original Edition available online at Caltech<sup>3</sup>

**ORIGINAL EDITION:** The Original Edition was published in 1966. While it is now out-of-print, it can be found online here: <http://ned.ipac.caltech.edu/level5/Arp/frames.html><sup>3</sup>. The Atlas contained about 100

pages consisting of a few introductory pages and 85 pages of 4 images per page of the negative plates of Dr. Arp's 338 selected irregular galaxies.

Arp's Atlas of Peculiar Galaxies was not well received by his peers at the time. They claimed the presentation was not significant enough statistically to be of interest (about 1-2% of all catalogued stars). Besides, astrophysics then did not have the tools to explain the **formation** of galaxies, let alone their **morphing**: Peculiar galaxies were simply not worth pursuing.

In **1973** the United Kingdom Science Research Council began a deep Southern Sky Survey similar to its northern counterpart using the 48" Schmidt in Australia which is a twin of the one at Mt. Palomar. Over the course of 7 years, Dr. Arp and Barry Madore examined 77,838 galaxies on 537 plates and found 6445 galaxies that were peculiar. This was 8%, not just 1-2% as in the northern survey. Peculiar galaxies could no longer be ignored. In **1987**, Arp and Madore published *A Catalogue of peculiar Galaxies and Associations*. It is available online at Caltech:

[http://ned.ipac.caltech.edu/level5/SPGA\\_Atlas/frames.html](http://ned.ipac.caltech.edu/level5/SPGA_Atlas/frames.html)

However, these findings still did not sway the mainstream astronomers who considered peculiar galaxies as freaks and did not matter statistically. Two things would change that:

First, "astronomers have classified galaxies according to their appearance at visual wavelengths - in blue light. But the advent of radio, ultraviolet, and near-infrared observations has shown that a galaxy's appearance can substantially morph with wavelength. A normal spiral can appear distinctly abnormal depending on whether it is seen in ultraviolet or near-infrared light. Dust as well as its core energy output can also affect a galaxy's appearance at wavelengths other than those in the visual band.

"The second development didn't dawn until **1995** and **1996** when the Hubble Deep Fields North and South brought to light thousands of previously unknown fragmented and distorted galaxies extending out to the edge of the visible Universe, each within a parcel of sky no larger than a pin-point. Assuming these two opposing directions were not special exceptions to the overall distribution of galaxies, there had to be tens of billions of such galaxies dispersed across the sky. The remarkable Hubble Ultra Deep Field, released in March of **2004**, has further confirmed this.

"Taken together, the multi-wavelength observations and deep-field findings have significantly altered astrophysicists' idea of what a normal galaxy is. In fact, there are *no* "normal" galaxies. As Arp presciently wrote in his preface to *Atlas of Peculiar Galaxies*, 'when looked at closely enough, every galaxy is peculiar'."<sup>4</sup>

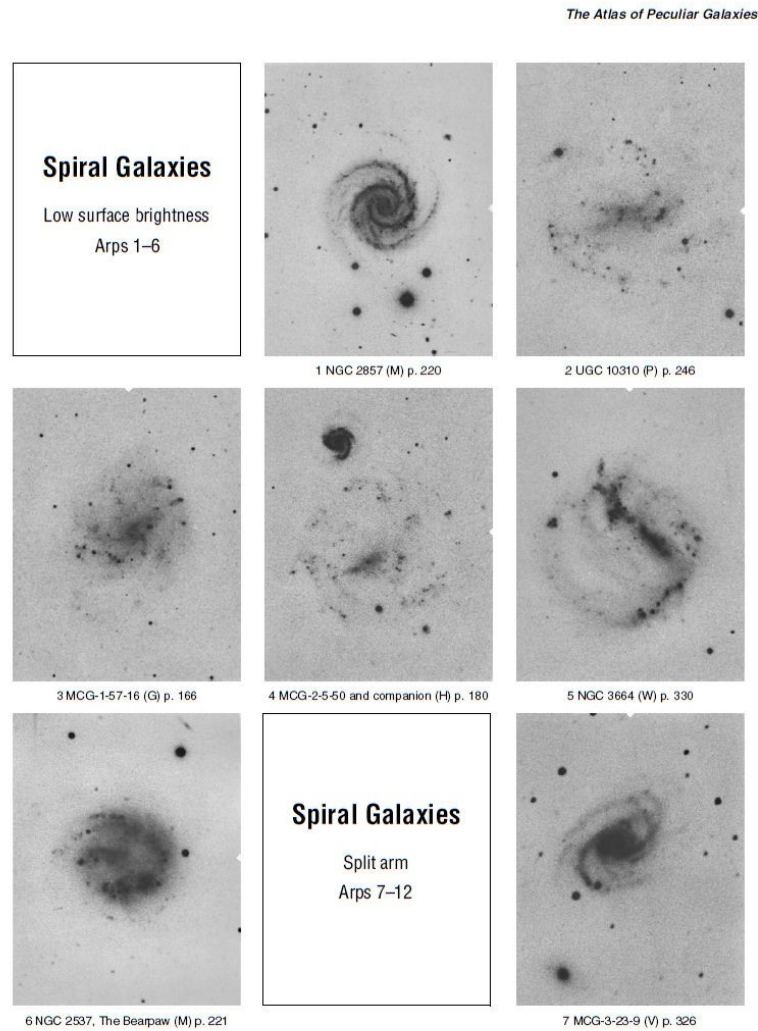
**REPUBLISHED in 2006:** Forty years later authors Jeff Kanipe and Dennis Webb have extensively expanded the *Arp Atlas*, and added the annotation to the title: "*A Chronicle and Observer's Guide*". The revised Atlas has 400 pages with 42 pages of original images. The new 'Chronicle' section has about 70 pages of history and orientation, and 26 Charts (A-Z) showing the location of all Arps. The Observing Guide has over 230 pages, combining CCD images taken by amateur observers of all 338 Arp galaxies, annotated schematic diagrams of each galaxy field and observers' notes. This Atlas is both an encyclopedia and a working guide. More detail on the new and revised sections follows:

- "**A Chronicle...**" Roughly 70 pages in the *Chronicle* cover the following topics:
  - The processes that make galaxies peculiar
  - Halton Arp's early life

- His initial work at Mount Wilson
- How and why he constructed the Atlas
- Why he left the Carnegie Institute
- The breakup between Carnegie and Caltech
- His controversial work on galaxy-quasar associations
- Profiles of some of Arp's most prominent discordant redshift cases

- **Republishing Original Scans:**

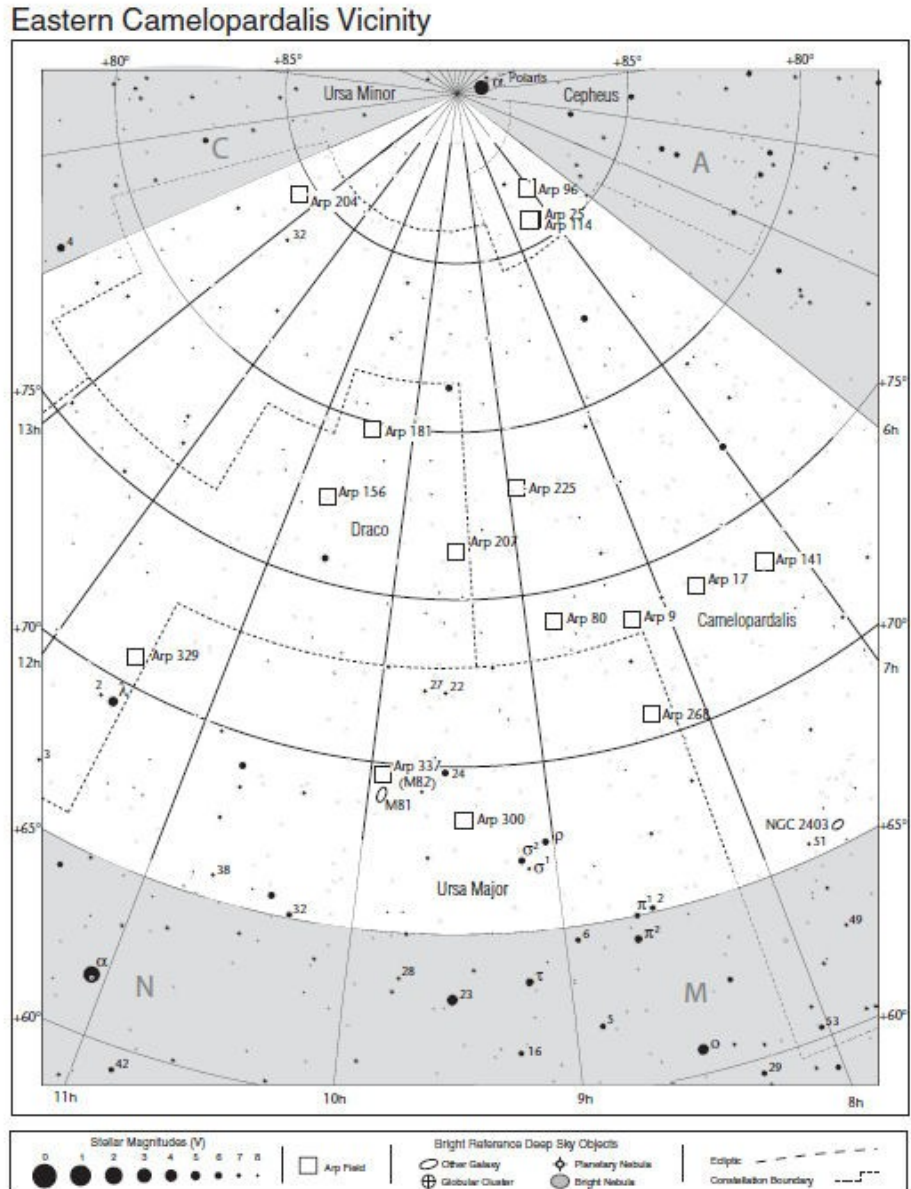
“The *Atlas* reprint contains prints from scans of intermediate photographic prints provided by Barry Madore which were several processing steps away from the original glass plates and were then used for the composite printing of the original *Atlas*”<sup>5</sup>. These have been adjusted somewhat to remove artifacts, scratches, etc., and are printed in the original Arp sequence annotated with the most common galaxy name, Chart letter and Observing Guide Page number. All 338 Arps are presented. Shown below is the 1<sup>st</sup> page of plates<sup>1</sup>:



• ... **“And Observing Guide”**: These 230 pages consist of a Chart Key, 26 Charts showing the locations by Constellation of all 338 Arp galaxies (which I refer to as ‘Arps’ from here on), Tables of Chart characteristics on the facing page, a collection of CCD images of the Arps in the Chart and notes from amateur astronomers on the pages following each chart. Examples are shown below:

- **Chart B<sup>1</sup>**:

**Chart B**





- Chart B Information on facing Page<sup>1</sup> (Ra/Dec = J2000):

## Chart B

### Eastern Camelopardalis Vicinity

Arp	Involved Galaxies	Peculiarity	Dim Maj x Min	Or	Mag (max)	RA h m	Dec °	Con	U2K Chart 1Ed 2Ed	Note
9	NGC 2523	Spiral with split arm	3.6 x 2.8	E	11.9	8 14.99	73 34.8	Cam	7 ✓ 6 ✓	
17	UGC 3972	Spiral with detached segments	2.2 x 1.7	W	14.6	7 44.72	73 49.2	Cam	7 6 ✓	
25	NGC 2276	Spiral with one heavy arm	5.5 x 4.3	N	11.4	7 27.22	85 45.3	Cep	1 ✓ 1 ✓	?
114	NGC 2276 and NGC 2300	Ell close to and perturbing spirals	11 x 8.5	W	11.4	7 29.99	85 43.5	Cep	1 ✓ 1 ✓	?
80	NGC 2633	Spiral: large HSB comp on arm	3.6 x 2.8	S	12.2	8 48.11	74 6.0	Cam	7 ✓ 6 ✓	?
96	MCG+14-4-10 and -11	Spiral: elliptical comp on arm	3.6 x 2.8	E	14.6	7 3.01	86 34.2	Cep	1 1 ✓	
114	(See Arp 25)	Ell close to and perturbing spirals								
141	UGC 3730	Material emanating from elliptical	2.7 x 2.1	S	13.2	7 14.33	73 28.2	Cam	7 ✓ 15 ✓	
156	UGC 5814	Disturbed with interior absorption	2.7 x 2.1	E	15.0	10 42.63	77 29.7	Dra	8 5 ✓	
181	NGC 3212 and NGC 3215	Narrow filaments	3.6 x 2.8	W	13.0	10 28.28	79 49.3	Dra	8 ✓ 5 ✓	?
204	UGC 8454	Material ejected from nucleus	2.7 x 2.1	E	15.6	13 23.00	84 30.4	Cam	1 1 ✓	
207	UGC 5050	Material ejected from nucleus	2.2 x 1.7	S	15.4	9 31.17	76 27.8	Dra	8 6	
225	NGC 2655	Amorphous spiral arms	11 x 8.5	W	10.1	8 55.65	78 13.5	Cam	7 ✓ 6 ✓	H
268	UGC 4305, Holmberg II	Irregular clumps	11 x 8.5	S	10.7	8 19.20	70 43.5	UMa	22 ✓ 15 ✓	
300	UGC 5028 and UGC 5029	Double galaxies	3.6 x 2.8	W	13.4	9 28.00	68 25.0	UMa	23 ✓ 14 ✓	
329	UGC 6514, Hickson 55	Galaxy chain	2.7 x 2.1	N	15.9	11 32.12	70 48.9	Dra	25 13	R ?
337	Messier 82, NGC 3034	Unique	11 x 8.5	E	8.4	9 55.86	69 40.8	UMa	23 ✓ 14 ✓	M H

#### Observing Highlights

Big and Bright	337 (Messier 82)
Overlaps	114 contains 25
Small and Faint	156, 204, 207

#### Chart Characteristics

Contains 16 Arp fields with 15 peculiarities.  
 Field sizes range from 2.2 arcminutes to 11 arcminutes.  
 Visible North of 0° Latitude.  
 Midnight (Standard Time) culmination in early February.  
 Chart area is covered by the other atlas charts:  
 Sky Atlas 1–2, Norton's 1, Bright Star Atlas 1

#### Notes

?	Uncertainty in naming
H	Astronomical League Herschel 400 Program
M	Messier List
R	Discordant Redshift

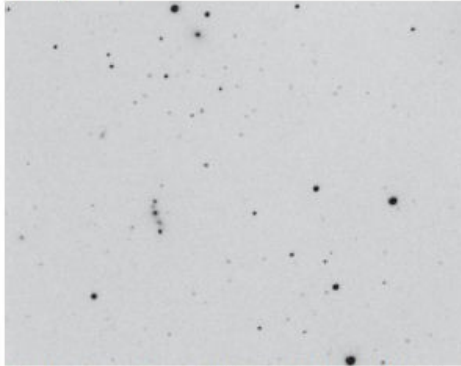
#### Arp 329, Hickson 55 Details

Hickson	Other Name	z	Mag	Size	Type
55A	PGC 35575	0.054	16.0	0.4'	SA0 pec:
55B	PGC 35572	0.052	16.9	0.3' x 0.2'	E pec
55C	PGC 35573	0.052	17.4	0.6' x 0.4'	SBa pec
55D	PGC 35574	0.054	17.6	0.3' x 0.2'	S0 pec:
55E	PGC 35576	0.123	18.0	0.2'	S

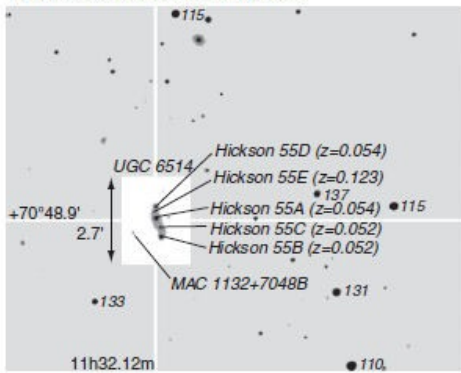
- **CCD Images of several Arps per page. Note: in the lower pair of images, the original Arp field is in a white background annotated with its size in arc-minutes: 2.7' and 11' respectively on this particular page<sup>1</sup>:**

**Chart B**

Arp 329, UGC 6514, Hickson 55  
Galaxy chain



Tim Hunter and James McGaha, 24-inch *f*/5 Newtonian, Apogee 7 camera, 60-second exposure.



**Visual Observations**

**Barbara Wilson** 20-inch *f*/4 Newtonian, 290x: At low power it is a linear blur. At higher power, when seeing settles down, three of the five galaxies are seen.

**David Tosteson** 25-inch *f*/5 Newtonian, 270x: After several minutes searching, four galaxies seen condensing out of the line. Component E probably not seen. Mag 13 star 4' to SE. In 36-inch: five Hicksons seen and MAC 1132+7148 SE of the main group. Galaxy W of 55A not seen.

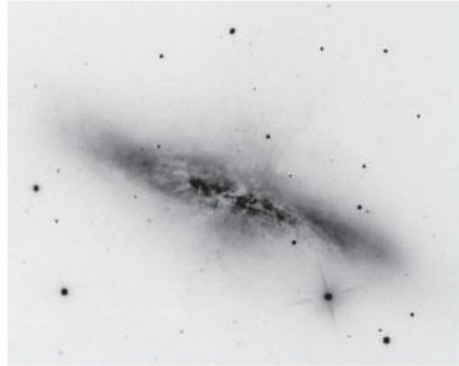
**Notes**

**Hickson 55A** mag 15.9, 0.2' x 0.2' and SA0 pec. See table at the start of Chart B for details of all galaxies.

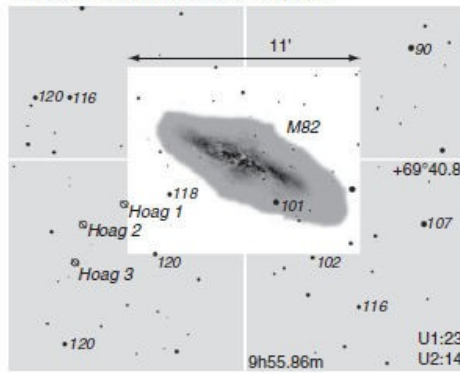
**Naming Irregularity** Hickson and VV letters are different.

**Challenge** Separate the five galaxies.

Arp 337, Messier 82, NGC 3034  
Unique



Robert Gendler, 12.5-inch Ritchey-Chrétien at *f*/9, SBIG ST-10XME camera, 120-minute exposure.



**Visual Observations**

**Barbara Wilson** 20-inch *f*/4 Newtonian, 290x: Long cigar-shaped with three dark lanes cutting across the width. Mottled appearance.

**David Tosteson** 18-inch Newtonian, 350x: 10'-12' with many dark stripes perpendicular to the plane of the galaxy, especially just N of the middle. Mottling, especially in the center.

**Notes**

**NGC 3034** Messier 82 is mag 8.4, 11.4' x 4.3', 10 sp, and  $z = 0.00068$ .

**Arp's Notes** Internal explosion.

**Note** the arc of three mag 20 quasars ( $z = 2.05$ ) examined by Burbidge *et al.*, *Ap. J.*, 242:L55-L57.

**Challenge** The filaments projecting from the center.

**BRIGHTNESS AND SIZE OF ARPS:** The Arps range in Magnitudes all the way down to 18.0 with a field size from 68 x 53 arc-minutes (Arp 317, Leo Triplet) down to 2.2 x 1.7 arc-minutes. Two thirds of the image fields are 3.6 arcminutes or smaller. Many may be either too dim or too small for you to fully appreciate without specialized equipment. <sup>6</sup>

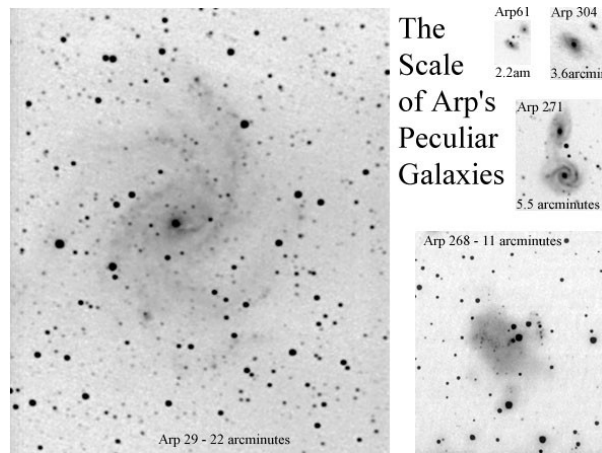
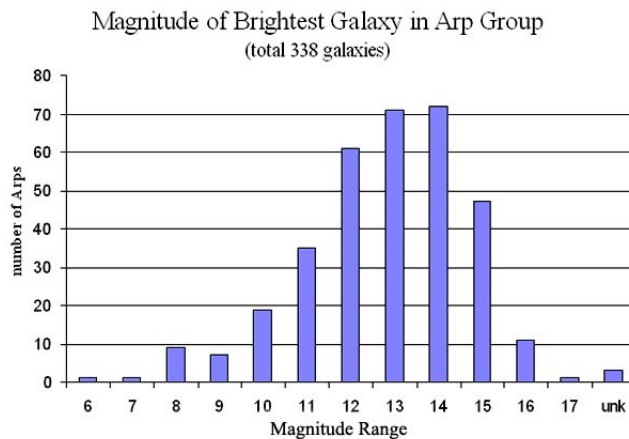


Illustration by Dennis Webb <sup>7</sup>



Histogram by Dennis Webb <sup>8</sup>

This is a case where the size of your equipment rules! But even scopes of 8" ~ 10" can satisfactorily see the brighter and larger Arps. Those of you with CCD imaging capability can image even smaller and dimmer Arps. Accordingly, here is a list of 19 of the brightest Arps  $\geq$ Mag 12.1 arranged by Arp Number as a starting point for you to explore a world of objects few others have seen:



## BIG AND BRIGHT ARPS

	Arp #	NGC	Messier	Mag	ArcMin	Ra	Dec	Con
1	16	3627	M66	9.7	11.0	11 20.25	+12 59.3	Leo
2	26	5457	M101	7.9	34.0	14 3.21	+54 24.0	UMa
3	37	1068	M77	8.9	3.6	2 42.67	0 0.8	Cet
4	76	4569	M90	10.3	11.0	12 36.79	+13 11.4	Vir
5	77	1097		9.2	11.0	2 46.27	-30 15.5	For
6	84	5395-5394	M90	11.4	5.5	13 58.58	+37 26.0	CVn
7	85	5194-5195	M51	8.4	23.0	13 29.87	+47 11.9	CVn
8	94	3226-3227		11.1	11.0	10 23.45	+19 51.9	Leo
9	116	4649	M60	9.8	11.0	12.43.66	+11 33.2	Vir
10	120	4438-4435		10.1	11.0	12 27.76	+13 2.0	Vir
11	153	5128		6.8	23.0	13 25.46	-43 1.1	Cen
12	244	4038-4039		11.1	22.0	12 1.83	-18 54.0	Crv
13	269	4490-4485	Cocoon	10.2	11.0	12 30.50	+41 39.5	CVn
14	270	3395-3396		12.1	3.6	10 49.88	+32 59.0	LMi
15	281	4631-4627		9.8	23.0	12 42.10	+32 32.4	CVn
16	286	5566 Group	Antenna	11.5	11.0	14 20.25	+ 3 57.0	Vir
17	317	Leo Triplet		9.7	68.0	11 19.30	+13 17.0	Leo
18	318	833 Group		12.1	11.0	2 9.46	-10 9.0	Cet
19	337	3034	M82	8.4	11.0	9 55.86	+69 40.8	UMa

**WHERE DO YOU FIND MORE INFORMATION ON THE ARPS?** Information about Arps is somewhat difficult to find since most Atlases do not list them. Then there is the problem of different synonyms. While the Observing Guide pinpoints the locations of all Arps, you may wish to look up additional information such as Distance, Red-Shift, etc. Star catalogues list some of them. For example there are 11 Messier objects, 29 Herschels, and 18 Hicksons. (See this list on Doug Webb's site: <http://arpgalaxy.com/intersec.html>.) His website also lists about 15 other sources.

Stellarium searches use Simbad which returns an NGC number and sky position without selecting an object: you have to select a nearby star to freeze the motion. At least you can find the constellation and general location by zooming out, or use the NGC number to consult other references.

Another excellent online source is the NASA/Ipac Extra Galactic Database (<http://ned.ipac.caltech.edu/>). I found 10 synonyms for Arp 192 and 46 for Arp 77! Of course the best place to find them is in the Atlas as they are listed both in Arp sequence and Ra/Dec by constellation in the Appendix along with finder charts by constellation in the Observer's Guide.

In preparing this article, I had the opportunity to visit Jeff Kanipe's website several times. <http://jeffkanipe.wordpress.com/> On one of my visits, I noticed the following fascinating vignette, reprinted with the permission of Jeff Kanipe:

#### THE MYSTERY OF THE MISSING SPIKE IN THE GALAXY ARP 192

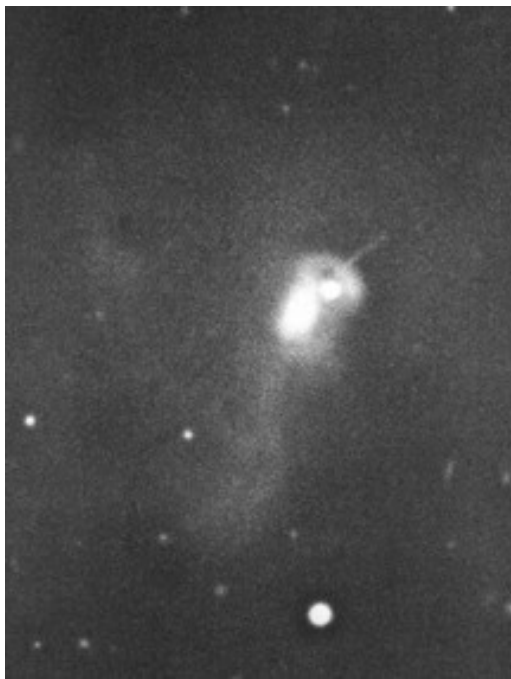
"An odd feature that for more than 40 years was thought to be structurally associated with a peculiar galaxy has been identified as the superposed trail of a main-belt asteroid that happened to be crossing the galaxy as it was being photographed in **1964**. An amateur astronomer who imaged the galaxy in **2008** first noted the modern lack of the 'spike.'

"The mystery begins in 1966, when astronomer [Halton C. Arp](#) published a compilation of 338 photographs of highly asymmetrical galaxies and galaxy groups taken at [Palomar Mountain](#) in Southern California. Entitled "[The Atlas of Peculiar Galaxies](#)," the book was one of the first serious inquiries into the nature of what was, at the time, a small class of disturbed galactic systems that were neither spiral nor elliptical in form. One of these galaxies, [number 192](#) (also known as NGC 3303), has a distinctive spike appearing to jut from the galaxy's bulbous northwest side. Based on its appearance in the Arp Atlas, Peter Nilson described the feature as a "sharp jet" in his **1973** Uppsala Galaxy Catalogue.

"Forty years after the Atlas was published, two astronomy writers, Jeff Kanipe and Dennis Webb, published their commemorative book "[The Arp Atlas of Peculiar Galaxies: A Chronicle and Observer's Guide](#)" (Willmann-Bell, **2006**). The book recounts Arp's research leading to the compilation of the Atlas and reproduces all of the original Atlas images, along with modern images made by amateur astronomers. Ironically, the authors ranked the Arp 192 spike/jet as a "challenge" for advanced amateurs to photograph.

"In August **2009**, Kanipe and Webb learned that an amateur astronomer in Minnesota, Rick Johnson, had made a deep image of Arp 192, one he thought should have revealed the spike's presence. Johnson reported, however, that the spike was not visible. Suspecting that Johnson's exposure probably had not gone deep enough, Kanipe consulted recent images of Arp 192, the best being from the [Sloan Digital Sky Survey](#). He inverted the image to a negative format, converted it to gray scale, and then contrast-enhanced it so the resulting image approximated the density of the one in the Atlas. No vestige of the spike was apparent. It had truly vanished. "This was an exciting turn of events, and not a little disturbing," says Kanipe. "Galactic structures do change, but they change over periods of several hundred million years. The human race hasn't existed long enough to observe dramatic structural changes in any galaxy, but here was a feature that had evaporated in 40 years, and nobody noticed." Possible explanations for the spike's conspicuous absence included it having been a photographic artifact, a plate defect, or an asteroid trail. The orbits of thousands of minor planets have been so well determined that by calculating "backward" in time one can ascertain an asteroid's position on any day in the past. Archivists at the [Carnegie Observatories](#) headquarters in Pasadena, California, confirmed to Kanipe that the original plate was taken on 19 February **1964**. Brian

Marsden, director emeritus of the Minor Planet Center at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, subsequently confirmed that minor planet (84447) 2002 TU240 would have been located near the sky coordinates for Arp 192 on that date in **1964**. With that, the mystery was solved. The asteroid was discovered on 6 October **2002** by the Near Earth Asteroid Telescope on Haleakala, Maui, Hawaii. The Arp 192 Atlas image is the earliest known prediscovery image of this object. Just after Thanksgiving 2009, Kanipe learned from Marsden that minor planet (84447) 2002 TU240, now bore a different name: 84447 Jeffkanipe. The extraordinary coincidence of an asteroid trail being captured as it happened to transit a small peculiar galaxy understandably led to the erroneous conclusion that the spike was an intrinsic feature. Thereafter, it became part of the astronomical literature; if not for the question posed by an amateur astronomer, it might still be.”<sup>9</sup>



Left Image: Original 1964 image of Arp 192 with “spike” in upper right (Shown as positive)<sup>3</sup>

Right: 2008 Image by Rick Johnson, NO SPIKE<sup>10</sup>

Here is a wide-field large image taken by Rick where you can see two Minor Planet trails SW of the Arp near the triangle of bright stars:<sup>11</sup>



Rick Johnson has a fascinating post on CN telling his side of the story and shows both the side-by-side and wide-field views above:

<http://www.cloudynights.com/ubbthreads/showflat.php/Cat/0/Number/3352987/page/0/view/collapsed/sb/5/o/all/fpart/all/vc/1>

- **Wikipedia:** On this site you will find a 42 page article entitled *Atlas of Peculiar Galaxies*. After a brief introduction, the *Contents* list all 338 of Dr. Arp's peculiars in the 5 categories and 39 sub-categories. Following the Contents is a listing of Arps in sequence with a synonym and notes. Most interesting are the 40 color photographs of selected galaxies which are breath-taking. 4 of these are shown below:

[http://en.wikipedia.org/wiki/Atlas\\_of\\_Peculiar\\_Galaxies](http://en.wikipedia.org/wiki/Atlas_of_Peculiar_Galaxies)



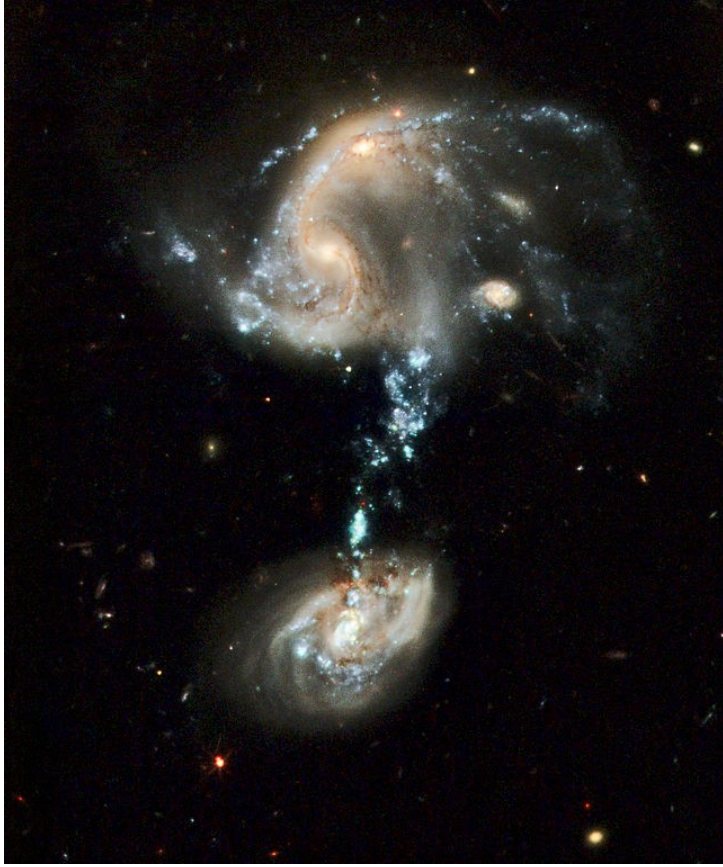


Arp 85, M51, the Whirlpool, Companion on Arm <sup>12</sup>



Arp 148 Mayall's Object, With Associated Rings <sup>12</sup>





Arp 194, Material Ejected From Nuclei<sup>12</sup>



Arp 242, the Mice Galaxies, Appearance of Fission<sup>12</sup>

<sup>12</sup> These (4) images are from : [http://en.wikipedia.org/wiki/Atlas\\_of\\_Peculiar\\_Galaxies](http://en.wikipedia.org/wiki/Atlas_of_Peculiar_Galaxies)

**FURTHER READING:** Below are several sites you may wish to visit:

- **Astronomical League:** They have an Arp Observer's Club which gives recognition to those who have visually observed or imaged 100 of the peculiar views.

<http://www.astroleague.org/al/obsclubs/arppec/arppec.html>

- **Dennis Webb's Website:** This is a great site, a good read with over 100 links to reference material. There is a very funny and well-written account of his research saga starting in 1995 to compile a catalogue of synonyms, data location, field size, magnitudes, etc. (<http://arpgalaxy.com/story/index.html>).

Dennis' Website: <http://arpgalaxy.com/>

- **CloudyNights.com:** There is a blog on this article which can be found at:

<http://www.cloudynights.com/ubbthreads/showflat.php/Number/5934475>

Please feel free to post any thoughts you may have about the Atlas on this blog.

**CONCLUSION:** Both Arp's original and new editions are important in the evolution of astronomy. The information is well presented: the Chronicle alone is an important piece of history. The stories behind both the original and new editions are truly amazing and well worth the read. If you are a DSO observer, the Atlas is a "must-have". If you already have the Atlas, I hope I have been able to share new material for you. One tip if you are imaging the Arps: Arp 148 is receding at 10,171 km/s which is about 21,969,360 MPH. You may want to consider 10 minute exposures rather than 100 minute exposures so the object does not drift out of your field of view.

**SPECIAL THANKS:** Thanks to Willmann-Bell, Dennis Webb, Jeff Kanipe and Rick Johnson for their generous permission to use their material in this article.

**CREDITS of sources used in Article:**

- |     |                       |               |   |
|-----|-----------------------|---------------|---|
| 1.  | Arp Atlas             | Willman-Bell  | <a href="http://www.willbell.com/HANDBOOK/arp.htm">http://www.willbell.com/HANDBOOK/arp.htm</a>                             |
| 2.  | Hubble Tuning Fork    | NASA/ESA      | <a href="http://en.wikipedia.org/wiki/File:HubbleTuningFork.jpg">http://en.wikipedia.org/wiki/File:HubbleTuningFork.jpg</a> |
| 3.  | Original Atlas        | Caltech       | <a href="http://ned.ipac.caltech.edu/level5/Arp/frames.html">http://ned.ipac.caltech.edu/level5/Arp/frames.html</a>         |
| 4.  | Arp Atlas, Page xiv   | Willmann-Bell | Reprinted with permission   |
| 5.  | Arp Atlas, Page 10    | Willmann-Bell | Reprinted with permission   |
| 6.  | Website               | Dennis Webb   | <a href="http://arpgalaxy.com/">http://arpgalaxy.com/</a>   |
| 7.  | Scale of Arp Galaxies | Dennis Webb   | <a href="http://arpgalaxy.com/arpscale.jpg">http://arpgalaxy.com/arpscale.jpg</a>   |
| 8.  | Histogram of Mags     | Dennis Webb   | <a href="http://arpgalaxy.com/magdist.jpg">http://arpgalaxy.com/magdist.jpg</a>   |
| 9.  | Website               | Jeff Kanipe   | <a href="http://jeffkanipe.wordpress.com/">http://jeffkanipe.wordpress.com/</a>   |
| 10. | CN post (See above)   | Rick Johnson  |   |

11. Ibid

12. Arp Photos

Wikipedia

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"The difference between Stupidity and Genius, Genius has its limits." Albert Einstein /