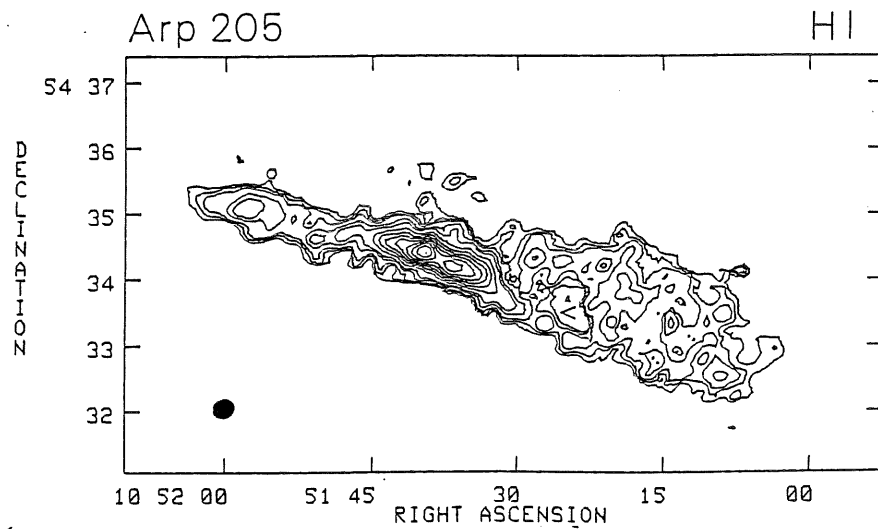
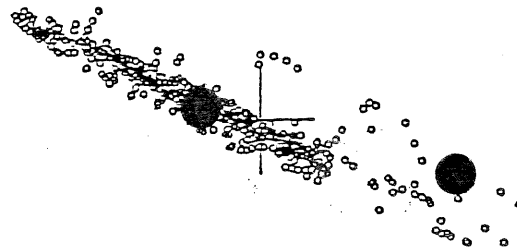


THE DAVID DUNLAP DOINGS

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Arp 205



Galaxies in Collision: The upper panel shows a model of the system Arp 205, which consists of NGC 3448 and its companion UGC 6016; the galaxy cores are shown by the black dots. The lower panel shows the HI distribution in the system at the same scale. From Louis Noreau's Ph.D. thesis (abstract appears in this issue).

MISCELLANY

Wendy Freedman and Barry Madore were married on June 23 in a lovely outdoor ceremony at the Freedman farm in Schomberg. They left the next day for a "working honeymoon" in Chile.

Peter Wizinowich (B.Sc. graduate and former resident astronomer at Las Campanas) is to be married on August 3 to Janice Ingrid Wonders in Hawaii, where Peter is a staff member at CFHT.

Congratulations to Martin and Martha Duncan on the birth of their daughter Claire Elizabeth, on June 15; see the "Galaxy Formation" conference report for further comments.

The IAU has recently decided to honour those who have been members of the IAU for 50 years or more. The list of such members includes Helen Hogg, who was elected to membership in 1932, and former staff member Peter Millman, who was elected to membership in 1935.

Tom Wells has successfully applied for admission to the U. of T. Faculty of Education in the fall (only about one applicant in ten is accepted). We wish him well in his future studies and teaching career.

Born to Kenneth & Virginia Topley, a son, Christopher John, 8 lbs 5 oz on July 30, 1985. - First grandchild for Joan Tryggve.

CASCA '85 AND THE FIFTIETH ANNIVERSARY WEEK

The annual scientific meeting of the Canadian Astronomical Society was held in the Department from May 27 to 31, 1985, coincident with the fiftieth anniversary week of the DDO. By all reports, the week was a great success. Over a hundred participants from outside Toronto were in attendance.

At the opening reception in University College on May 27, Principal Peter Richardson gave a fascinating verbal tour of the College building, and outlined its connections with the growth of science teaching and research at the University of Toronto. He and Don Fernie then "unveiled" the DDO Fiftieth Anniversary Booklet, which was partially financed by the College.

On May 28, the Canadian Astronomical Society and the Planetarium Association of Canada sponsored a very successful joint session on "Education in Astronomy". This was followed in the evening by the first annual Helen Sawyer Hogg public lecture, given by Owen Gingerich of Harvard University. Happily, Helen was able to be present at the lecture, and at the dinner which preceded it and the reception which followed. Several hundred people attended the lecture.

The formal scientific sessions began on May 29. There were excellent review papers by Gilles Fontaine and Don Vandenberg (on "White Dwarfs" and "The Ages of the Globular Clusters", respectively), and a good balance between contributed oral papers and poster presentations. On the evening of May 29, Charles Townes delivered the Petrie Memorial Lecture, in which he described some of the exciting new developments in our understanding of "The Galactic Centre". The conference banquet was held at the Park Plaza Hotel on the evening of May 30, featuring an excellent meal of poached salmon and some appropriate dinner music - nostalgic piano pieces from the era of the opening of DDO.

Interspersed among the scientific sessions were special meetings and sessions devoted to national facilities and other areas of interest. Summaries of these sessions have recently been published in *Cassiopeia*. A full three hours were devoted to the annual business meeting, but even this time was barely adequate to discuss all the matters of interest and concern.

The highlight of the week (at least for the locals) was the fiftieth anniversary celebration on the evening of May 31. The day began ominously, with disastrous tornados which caused extensive damage and loss of life only a few tens of kilometres from the Observatory. By early evening, however, the skies had magically cleared. About 150 participants gathered in the dome to hear short speeches by Don Fernie, George Connell (President of the University of Toronto), John MacLeod (President of the Canadian Astronomical Society) and Al Duffy (Mayor of Richmond Hill). The Hart House Chorus, stationed around the catwalk, contributed musical interludes. The participants then retired to the Administration Building for a tour of the premises, and appropriate refreshments (birthday cake!).

Dozens of members of the Department contributed to the success of the week, and all agreed that they would not want to do it again - at least for a decade or so. Nevertheless, it was an enjoyable and memorable celebration of the Observatory's first fifty years, and an optimistic preview of the next fifty.

John Percy

GALAXY FORMATION

CITA and the University of Toronto were hosts to the "Galaxy Formation" conference, June 19-21. Approximately 150 people registered, about 60 poster papers were presented, and the centrepiece of the event was the 10 invited talks. Martin Rees started with some general words of advice on how to run an Institute followed by an overview of recent ideas of how galaxies are thought to form. Len Cowie presented some new ideas and nondetections of primeval galaxies. Simon White talked about how the Hubble sequence might come about. Observational reality and difficulty was thrust forward by Richard Ellis, in a talk about very faint galaxies. The next morning Ken Freeman provided a solid array of data on our galaxy, followed by a bit of speculation as to the relation of thick disks and bulges. Paul Schechter considered the difficulties of forming ellipticals. That afternoon Jim Peebles and Jerry Ostriker put forth opposing views as to the relative importance of gravity and gas pressure in the formation of galaxies. The final morning featured CITA's incoming director, Scott Tremaine, discussing how galaxies observed today may be significantly different from the initial objects, due to dynamical evolution. In a similar vein, Jim Gunn argued that disk galaxies grow slowly over the course of cosmic time via infall. All speakers were entertaining far beyond the call of duty. A successful feature of the meeting was to give the audience almost equal time to the speaker, allowing a full range of remarkably frank discussion to emerge.

The Local Organizing Committee, chaired by Martin Duncan and gracefully assisted by numerous students, had a particular success in the "cruise to nowhere" around the Toronto harbour. Science talk ran so high that Martin had to take quite a lot of excess spirits away afterward (Chris Pritchett and Serge Pinault pitched in on that). Besides providing an organization that ran so smoothly that people had only the theories to complain about, Martin assisted Martha, his wife, to bring new life into the world on the Monday at the beginning of that week (whew! great timing).

Ray Carlberg

Jets Over Toronto

A conference entitled "Jets from Stars and Galaxies", sponsored by the Canadian Institute for Theoretical Astrophysics (CITA), was held at the University of Toronto from June 24-27, 1985. This workshop brought together astronomers, both observers and theorists, studying the recently recognized phenomenon of collimated bidirectional outflow from star forming regions, young stellar objects (YSOs), and collapsed stellar remnants, with astronomers working on the more "mature" subject of jets in active galactic nuclei (AGN) and quasars.

While the study of jets in extragalactic sources benefits from two or more decades of observational data, and has blossomed with the completion of the VLA, the difficulties of having only morphological data, of not having direct indicators of flow velocity or even of the existence of fluid outflow, and of not knowing the jet density, etc., have hampered the development of physical models. By contrast, for collimated stellar outflows data on the velocity field, density of the flow, etc. are directly obtainable, providing better constraints on models. The primary goal, and achievement, of this conference was to provide a forum for the exchange of information and ideas among astronomers studying these possibly similar yet very diverse phenomena. Whether it is possible to develop a unified model that adequately explains the existence of jet-like structures with sizes as small as one hundredth of a parsec and as large as 1 Mpc, with ejection velocities of .001c to greater than .98c remains to be seen. In any event, it would appear that jets are good tracers for regions of mass concentration with rotation since both stellar and AGN jets appear to form along the rotational axis of accretion disks around compact objects.

The chairman of the local organizing committee, Dick Henriksen (CITA, Queen's), kept this very much a "working" meeting with the 100 or so participants (from at least four continents) presenting more than 60 talks and 30 poster papers in a schedule that ran from 8:30 a.m. to 6 p.m. daily. (The proceedings of the conference will appear as a special (refereed) insert to the Canadian Journal of Physics in the spring of 1986.) The enthusiasm of the audience was such that all the talks were well attended and sessions frequently ran overtime. In fact, the last speaker of the first day was forced to abbreviate his talk so that a 7:00 p.m. examination could proceed in the same room. Evenings, at least what was left of them, were free so that the local restaurants and sights could be enjoyed. A well-attended wine and cheese reception was held on the Sunday evening preceding the meeting. Weather in Toronto was excellent during the week of the conference. All things considered, the meeting went very well and reflected well on the newly formed CITA and astronomy in Toronto.

Raymond Rusk

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Ray Carlberg

THE STUDY OF VARIABLE STARS USING SMALL TELESCOPES

This meeting was held in the Department from July 11 to 14. It attracted about 60 participants from as far away as Bermuda, Ireland, Belgium and Australia - a mixture of professional and serious amateur astronomers. Its purpose was to review the scientific results which could be obtained by studying variable stars visually, photographically and photometrically, and to address such current problems as automation, coordination and archiving of observations. There were discussions of near-IR and spectroscopic studies of variable stars, and a provocative look into the future of small-telescope astronomy by Slavek Rucinski. Other local people on the program included Christine Clement, Don Fernie, Alex Fullerton, Bob Garrison, John Percy, Ernie Seaquist, Chris Stagg and Doug Welch.

As well as the scientific sessions, there were the usual social events which have become traditional at Toronto meetings. These, together with the relatively small size of the meeting, encouraged a great deal of useful interaction between the participants, and this was perhaps the most valuable aspect of the meeting. I am about to begin editing the proceedings of the meeting, which I hope will be a coherent and comprehensive guide to the work which can be accomplished in the area of variable stars, using small telescopes.

I extend a special thank-you to Anne Chreptak, Esther McCleary, Joan Tryggve and Maria Wong, who helped so much with the meeting, and who are undoubtedly grateful to know that this is the last meeting in the Department in the foreseeable future!

John Percy

THE PEEL SUMMER ACADEMY

The Peel Summer Academy is a new summer program for gifted children, jointly sponsored by Erindale College and the Peel Board of Education. From July 8 to 19, 65 grade 4 to 6 students were in residence at Erindale College, taking academic courses in the morning, creative skills classes in the afternoon, and cultural activities in the evening. From July 22 to August 2, 60 grade 7 and 8 students will take part in a similar program. All of these students are in the top 2 to 5 percent of their age group intellectually, and are in special or enriched classes during the school year. In connection with the Academy, the Faculty of Education of the University of Toronto is presenting a course on teaching gifted children, and the teachers taking this course are assisting with the Academy program.

My main responsibility has been to arrange the morning academic courses, and they span the full range from the sciences to the humanities. Needless to say, the most popular is astronomy. Petrusia Kowalsky and I are each teaching a section of an astronomy course, and between us we have 35 of the 65 students in the grade 4 to 6 section of the Academy. We were not able to schedule an astronomy course for the grade 7 and 8 section, but all of the students in this section will visit DDO on July 29. The grade 4 to 6 section visited DDO on July 15; they were certainly the most enthusiastic (and noisy) visitors in many a year.

To work with these children is both challenging and satisfying. They are enthusiastic and uninhibited, interested and intensely curious. Their grasp of sophisticated scientific concepts rivals and sometimes exceeds that of our first-year students. We look forward to having some of them in our graduate department in a decade or so!

John Percy

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John Percy

1001 Arabian Nights

Appearing at Erindale on Mondays to give a tutorial is generally a routine sort of event. Little did I know that winter Monday that John Percy would walk into the tutorial room and ask if I was interested in going to Saudi Arabia. I replied that I didn't think my tutorial has been THAT bad. Much to my relief, he explained that an engineering consulting firm in Toronto, DSMA Atcon, required the services of an astronomy graduate student to install a telescope and that my name had come up. A frantic week of discussions followed and before I knew it I was Saudi-bound.

The terms of the contract with which I was involved included a publication ban and therefore I will decline to discuss the project itself. Nonetheless, the trip was an exciting and educational experience. I was accompanied by a DSMA employee, Andy Robertson, who was skilled in engineering matters. The Saudis are an extremely hospitable people and we were certainly well taken care of during our stay. I was very impressed with the thoroughness with which any task was undertaken and completed.

Many of the images one has of Saudi Arabia are quite accurate. It IS very hot and it IS mostly desert. There are even camels in the desert, although they are rapidly being replaced by Toyota and Nissan pickups. The landscape is quite varied and beautiful. A distinction is made in Saudi Arabia between real desert (shifting sand dunes and NO life) and what we would call desert (scrub). We had the good fortune to meet with Bedouins on several occasions. Contrary to their storybook image, they are a very friendly group who will invite you to dine with them without the slightest provocation! A number of creatures like scorpions and three-inch long red wasps made things interesting, but the heat generally kept them sluggish and harmless --- come to think of it, the heat did about the same for us! The night sky is, of course, dark and beautiful, and the very pleasant night-time temperatures encourage interest in star-gazing.

I am indebted to my hosts in Saudi Arabia for being so helpful and friendly, and for educating me about a world of which I knew very little before my trip.

Douglas of Arabia

Harry Guetter (MA, 1963), has written to say that a minor planet has been named after Jack Heard. The following is extracted from Minor Planet Circular 9770 of July 2, 1985:

(3023) Heard = 1981 JS

Discovered 1981 May 5 by E. Bowell at the Anderson Mesa Station of the Lowell Observatory.

Named in memory of John Frederick Heard (1907-1976), professor of astronomy at the University of Toronto and fourth director of the David Dunlap Observatory. An outstanding and meticulous spectroscopist, he specialized in spectroscopic binaries and stellar radial-velocity standards. In addition, he was a dedicated teacher who helped train many Canadian astronomers. Citation prepared by H. Guetter.

Harry has long been a staff member of the Flagstaff Station of the U.S. Naval Observatory, and, as he told me at the June AAS meeting in Charlottesville, Virginia, harbours happy memories of his days at DDO. We are all grateful to him for his role in this naming, and, I am sure, concur whole-heartedly with the citation he prepared. It is a well-deserved honour and salutation to the memory of an outstanding Canadian astronomer.

Don Fernie

M.Sc. THESIS ABSTRACT

*Calibration and Population Models of M82 Nuclear Sources
by Brian E. Glendenning*

Some simple first order population models of the nuclear sources in M82 are derived and discussed. Models involving constant injection of sources decaying exponentially with a common half life cannot be reconciled with observations. A model in which the sources are injected at a constant rate and decay with a common power law does fit the data. The derived decay law is: $S_6 \propto t^{-0.9 \pm 0.2}$.

If this model is correct the sources in M82, presumably supernovae or young supernova remnants, are not in the adiabatic (Sedov) phase of their evolution, for which the expected exponent of the power law is $-2/5$. The derived SN (injection) rate from this model is 0.2/yr, consistent with other estimates. Also, a systematic epoch to epoch zero-point shift in the flux density scale is removed, and new values of the source fluxes are derived.

Ph.D. THESIS ABSTRACT

A Detailed Study of the Amorphous Galaxy NGC 3448
by Louis Noreau

To further our knowledge of the relatively rare amorphous-type galaxies, we carried out a detailed study of the interacting galaxy NGC 3448. Three observational techniques were used: optical and radio continua, and 21cm line mapping. This study represents one of the first attempts to obtain an integrated view of the optical light distribution, the radio emission, and the H I morphology and dynamics of a galaxy.

B, V, and R images were secured with a CCD camera at KPNO. Colour index maps were produced. A remarkable variation in colour indices is visible across the face of the galaxy. The (B-V) of the southern half is similar to that of the arms of the latest type spirals. The redder regions in the north, and east of the centre are probably obscured by foreground material.

The radio continuum emission at $\lambda\lambda$ 22, 18, 6 and 2 cm was mapped at moderate resolution with the VLA. The radio brightness is dominated by nuclear emission. It is hypothesed that NGC 3448 could harbour a central star forming region as does M82.

We carried out a complete synthesis of the 21cm line emission with the VLA, and were able to separate the H I emission of NGC 3448 from that of its dwarf companion, UGC 6016. The latter has very regular dynamics, and its hydrogen distribution is similar to that in other galaxies of the same type. The H I morphology of NGC 3448 is quite perturbed due to the tidal interaction with UGC 6016. It is found that the inner part of NGC 3448 rotates rigidly. A peculiar double velocity profile, spatially coincident with the reddest parts of the galaxy was found. It appears to be tidal material reintegrated with the galaxy and causing the obscuration observed in optical.

A model of the encounter between NGC 3448 and UGC 6016 was constructed, based on the restricted 3-body problem. It satisfactorily reproduces most of the large-scale features of NGC 3448, and shows that the shape and dynamics of the galaxy are consistent with a tidal interaction. This makes NGC 3448 one of the few galaxies whose overall dynamics have been modelled.

Other data, in the far infrared and the ultraviolet confirm the existence of a burst of star formation in the central regions of the galaxy. It appears that the galaxy is a late-type spiral whose morphology and dynamics were changed by the tidal interaction with UGC 6016. The perturbation of the galaxy equilibrium provoked the starburst by causing interstellar matter to pile up in central regions of the galaxy.

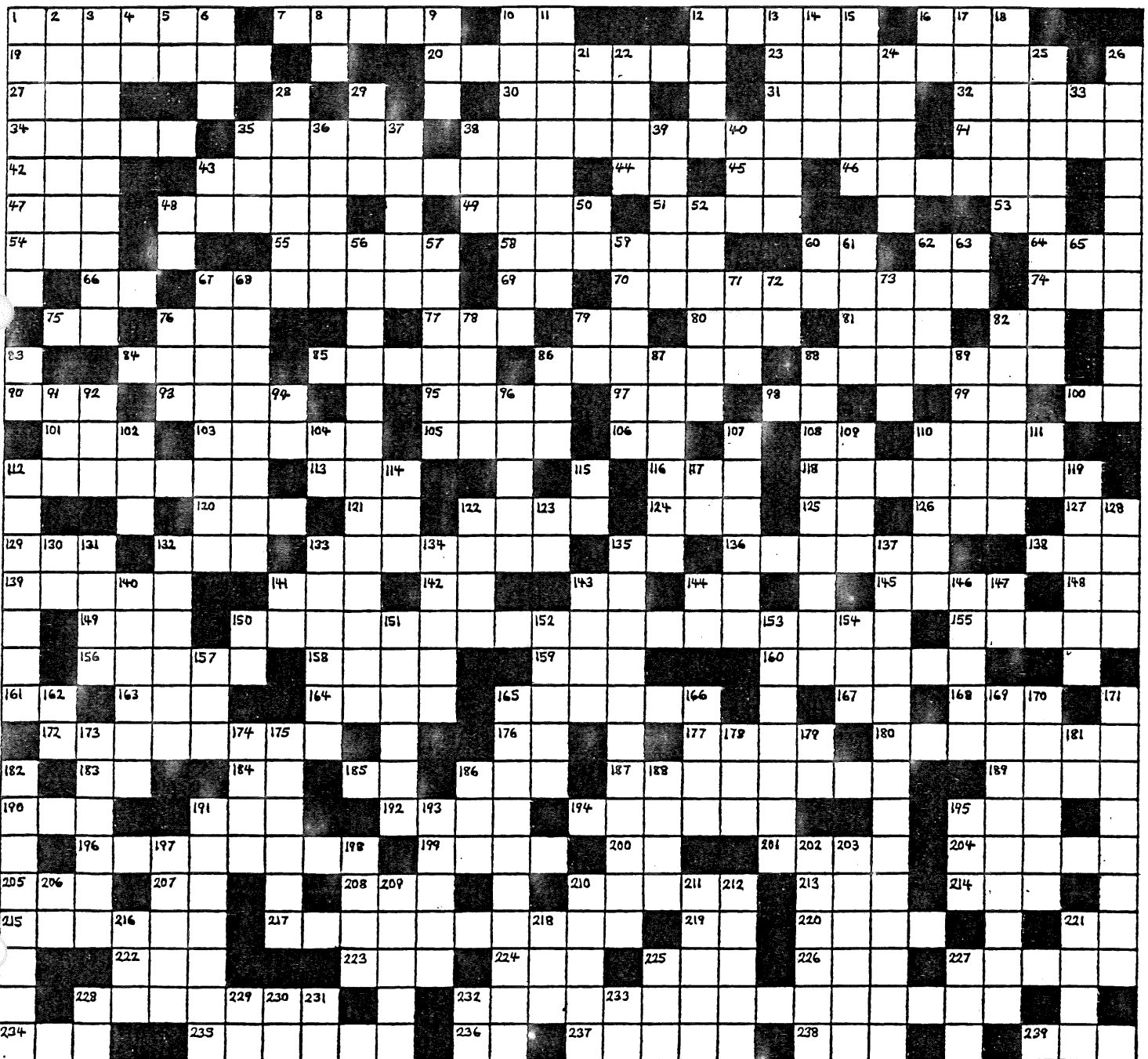
YET ANOTHER SUMMER DISTRACTION

Summertime is here at last. It is a time for fun and frolic. And what better way to while away those long afternoons than with a crossword puzzle. Particularly when it is too hot and humid to do anything else.

Many many moons ago, yours truly was stimulated to the point of madness to create an astronomical crossword puzzle. Here for your enjoyment is the humongous outcome. The faculty is considering adopting this format for future general exams, so graduate students beware.

Depending on how generous I am feeling, answers may be provided at some future date. In the mean time, I will be happy to lend my assistance to anyone with adequate financial backing.

Marshall McCall



ACROSS

- 1 Measure of reflectivity of a planet.
- 7 Long, narrow depression on Moon.
- 10 In surveying, point of known elevation:
Abbr.
- 12 ___ particles: helium nuclei.
- 16 Great Britain's air force: Abbr.
- 19 French popularizer of astronomy
(1732-1807).
- 20 M67: open star cluster in Cancer.
- 23 Kepler's third law of planetary motion.
- 27 Master of Public Administration: Abbr.
- 30 Long-period variable in Norma:
astronomical designation.
- 31 Malay apple.
- 32 Stratospheric absorber of ultraviolet
light.
- 34 Star in Ursa Major.
- 35 State of matter.
- 38 Alexandrian astronomer, first person to
accurately measure Earth's circumference.
- 41 Swiss mountaineer.
- 42 Garlock, Inc.: New York Stock Exchange
abbr.
- 43 ___ magnitude: measure of star's total
energy output.
- 44 Spiral galaxy with large nucleus and
tightly wound arms: Hubble's
classification.
- 45 River in Siberia.
- 46 Related collection of meteoroids.
- 47 Letter of Old English alphabet.
- 48 Point on celestial sphere directly below
observer.
- 49 Canadian communications satellite.
- 51 American theoretical and computational
astronomer, specialists in study of
orbital motions.
- 53 University of Oxford: Abbr.
- 54 ___ Paulo: Brazil's largest city.
- 55 ___ limit: telescope's minimum
resolvable separation of two star images.
- 58 Sundial's shadow-caster.
- 60 Densest known element: Symbol.
- 62 Element most used for coating mirrors:
Symbol.
- 64 Main constituent of galactic nebulae.
- 66 Considerably abundant element in
T Tauri stars: Symbol.
- 67 Radio observatory in Puerto Rico.
- 69 For example: Abbr.
- 70 Branch of astronomy dealing with
determination of celestial positions
and motions.

ACROSS

- 74 Not in.
- 75 Egyptian Sun god.
- 76 Comet 1970g.
- 77 French political party: Abbr.
- 79 Ninth element of Actinide Series:
Symbol.
- 80 Magic spell.
- 81 Member of the Double Cluster in Perseus.
- 82 Interstellar radical: chemical formula.
- 84 Undomesticated.
- 85 Shadow cone of a spherical body in
sunlight.
- 86 Swedish astrophysicist, co-winner of
1970 Nobel Prize for Physics.
- 88 Eleventh Astronomer Royal.
- 90 Away from: Prefix
- 93 That property of a body that gives
it inertia.
- 95 Gas around comet's head.
- 97 Continent: Abbr.
- 98 Asian animal: cross between yak
and zebu.
- 99 Form of 141 Down.
- 100 Element whose abnormal line strengths
typify spectra of peculiar A stars:
Symbol.
- 101 Scientists' name for 1957-1958: Abbr.
- 103 Plant's prickle.
- 105 Isaac's eldest son.
- 106 Only rare-earth element which does
not occur naturally: Former symbol.
- 108 Long-playing phonograph record: Abbr.
- 110 Cut with scissors.
- 112 Location of "The Rival of Mars":
Latin genitive.
- 113 U.S. atmospheric sounding rocket.
- 116 Gear tooth.
- 118 ___ test: method for testing and
measuring a mirror's figure.
- 120 Island in American Samoa.
- 121 As the acts show: Abbr.
- 122 Spectroscope part.
- 124 ___ glow: atmospheric fluorescence.
- 125 Heaviest noble gas: Symbol.
- 126 Component of spiral galaxy.
- 127 Unit of energy equal to 1.6×10^{-12}
ergs: Abbr.
- 129 ___ Yunus: Arab astronomer and keeper
of eclipse records (11th century).
- 132 "The Air Pump", southern constellation:
Abbr.
- 133 ___ Series: sequence of lines in
infrared region of hydrogen spectrum.

ACROSS

- 135 Former English coin: Abbr.
- 136 Formaldehyde sulfoxylate product used in colour printing.
- 138 Number of 133 Down in 3.262 of 63 Down.
- 139 Arrangement whereby light from reflecting telescope is reflected down polar axis to a fixed focus.
- 141 Nocturnal, flying mammal.
- 142 As below: Abbr.
- 143 That is: Abbr.
- 144 1×10^{-3} second: Abbr.
- 145 Star in Eridanus.
- 148 Second most abundant element in Earth's crust: Symbol.
- 149 Confronted.
- 150 ___ diagram: plot of absolute magnitude against temperature for a group of stars.
- 155 Prism used to transform ordinary light into plane-polarized light.
- 156 State in northeastern India.
- 158 Southeast observation post: Abbr.
- 159 Human-caused error: Abbr.
- 160 Colourless, gaseous hydrocarbon of paraffin series.
- 161 Seventh transuranium element discovered: Symbol.
- 163 Sea: French
- 164 Perorates.
- 165 "Packets" of energy possessed by photons.
- 167 Doctor of Theology: Abbr.
- 168 Unit for measuring absorbed doses of radiation.
- 172 Meteor not belonging to a shower.
- 176 Important city of ancient Sumer.
- 177 Upward force caused by air flowing across an airfoil.
- 180 Measure of degree of disorder of a system.
- 183 Logistical Support: Abbr.
- 184 Satellite of Jupiter.
- 185 Yes: German.
- 186 ___ component: Component of star's proper motion.
- 187 Variable stars used for measuring astronomical distances through application of the period-luminosity relation.
- 189 Network of lines on a map.
- 190 American Standards Association: Abbr.
- 191 Japanese coin.
- 192 128 cubic feet of cut wood

ACROSS

- 194 Television transmission circuit which provides signal for picture position adjustment along electron beam scanning line.
- 195 Anaconda or Python, for example.
- 196 Slight periodic oscillation of Earth's polar axis.
- 199 Prototype for red-giant, long-period class of pulsating variable stars.
- 200 Infrared-absorbing glass constituent: Chemical symbol.
- 201 Nonsense: British slang.
- 204 Resort town in California.
- 205 J. Dreyer's catalogue of nebulae, galaxies, and clusters: Abbr.
- 207 Element used in photographic film production: Symbol.
- 208 Belonging to the ethers or aldehydes: Suffix.
- 210 ___ micrometer: telescope instrument used to measure angular sizes and separations of celestial objects.
- 213 Scottish explorer and mapper of Canadian Arctic.
- 214 Observatory near Victoria, B.C., Canada: Abbr.
- 215 Acid neutralizer.
- 217 Science of finding and planning the position and course of a moving object.
- 219 Powerful Vietnamese dynasty of 15th century.
- 220 Long-period variable in Draco: astronomical designation.
- 221 Fifth most abundant element in universe (by number): Symbol.
- 222 Except that: Conjunction.
- 223 Gownlike outer garment worn by Arabs.
- 224 Library cataloguing and classification system: Abbr.
- 225 Phenyl glycidyl ether: Abbr.
- 226 Native tribe of Nigeria.
- 227 Mountain on the Moon.
- 228 English meaning of Menkar (alpha Ceti).
- 232 Most prominent absorption features of solar spectrum: 2 words.
- 234 The Sun, personified.
- 235 Luminous atmospheric phenomenon.
- 236 First person pronoun.
- 237 English meaning of the southern constellation Vela.
- 238 ___ Prior: star in Ophiuchus.
- 239 Great ___ Spot: semi-permanent Jovian feature.

DOWN

- 1 Ptolemy's 13 volumes on Greek astronomy.
- 2 Observatory in Argentina: 2 words.
- 3 Theoretical residue of extremely massive star exhausted of nuclear fuel, which has collapsed to oblivion: 2 words.
- 4 Ancient Babylonian god of wisdom.
- 5 Our Lord: Abbr.
- 6 Lyric poem.
- 8 Limestone island off Marseille.
- 9 Electronic position indicator: Abbr.
- 10 Only man with crater named after him on both Earth and Moon.
- 11 Minatory.
- 12 Association for Education by Radio-Television: Abbr.
- 13 First planetary satellite detected photographically.
- 14 German chemist, discoverer of fission of heavy nuclei.
- 15 Original location of vernal equinox.
- 16 Artificial language designed for international use.
- 17 Positive electrode.
- 18 French physicist, first person to reliably measure velocity of light by using a terrestrial method.
- 21 Systems Operation Test: Abbr.
- 22 First-discovered minor planet.
- 24 Parts of 169 Down.
- 25 Astronomy branch dealing with the study of the origin of the universe.
- 26 In binary star system, point in component star's orbit where it is closest to companion star.
- 28 Bright, exploding meteor.
- 29 Crater's edge.
- 33 Negative reply.
- 35 Ground containing grass and its roots.
- 36 Device used for accurate surveying.
- 37 "The Tail" of Cygnus.
- 38 Cenozoic or Paleozoic, for example.
- 39 Recurring 18-year cycle of similar eclipses.
- 40 Metal tool for cutting gears and tools.
- 43 In ancient Egyptian religion, the soul.
- 48 Frequency: scientific designation.
- 50 A knockout: Slang.
- 52 Flower part which bears pollen.
- 56 ___ figures: crystalline structure characteristic of cut, polished, and etched siderites.
- 57 Origin.
- 59 1968 discoverer of dust-obscured giant elliptical galaxy near Local Group.

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- 60 Sacred Hindu syllable symbolizing the "Absolute".
- 61 Second-stage engine cutoff: Abbr.
- 62 Outer covering of certain seeds.
- 63 9.4605×10^{17} centimeters: Abbr.
- 65 $1.49597893 \times 10^{13}$ centimeters: Abbr.
- 67 Fragmentation and vaporization of meteorite upon entering atmosphere.
- 68 Displacement of spectral lines of a luminous body towards longer wavelengths, indicating recession of that body: 2 words.
- 71 Transitional movement and revival period in Europe from 14th century to 17th century: Abbr.
- 72 Beast of burden.
- 73 Scandinavian god of thunder and war.
- 76 Collimate.
- 78 Brightest star in Puppis.
- 79 One of the halogens: Symbol.
- 82 Element used in atomic clocks for extremely accurate time measurement.
- 83 Proposed symbol for element 105 (honoring 14 Down).
- 86 Association of American Universities: Abbr.
- 87 Name given to hypothetical intra-Mercurian planet.
- 88 Class of very hot stars which eject shells of gas at high velocities.
- 89 In radio astronomy, small interstellar area which emits extraordinary energy at millimeter wavelengths.
- 91 ___ du Midi: French observatory in the Pyrenees.
- 92 U.S. satellite launched for geophysical studies: Abbr.
- 94 In order that: Conjunction.
- 96 Deciduous tree.
- 102 Periods of time, based on revolutions of Earth around Sun: Abbr.
- 104 Thor Heyerdahl's papyrus boat.
- 107 Emergence of one celestial body from behind or before disk of another.
- 109 Discoverer of 36 comets (world record).
- 110 Telescope image's linear size in relation to its angular size in sky.
- 111 Poet Laureate: Abbr.
- 112 In solar chromosphere, narrow jet of rising material.
- 114 Not: French.
- 115 In a place or condition of: Preposition.
- 117 Old Irish: Abbr.

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- 119 Set of n^r components which are functions of the coordinates of any point in n -dimensional space.
- 122 Object represented by 169 Down.
- 123 2.54 centimeters: Abbr.
- 128 Filamentary galactic nebula in Cygnus.
- 130 Sacred fig tree in India and Ceylon.
- 131 Torpid.
- 132 Undetectable, elastic medium formerly hypothesized to explain wave propagation through space.
- 133 Distance of object with stellar parallax of 1 second of arc.
- 134 Pointed ends of moon or planet in crescent phase.
- 135 Faint, diffuse glow in night sky, opposite Sun's position.
- 137 Approximate shape of Earth: 2 words.
- 140 Satellite of Mars.
- 141 Exist.
- 143 Extinct Andean civilization.
- 144 Micron: scientific designation.
- 146 ___ gases: argon, krypton, and neon, for example.
- 147 Twice; double: Prefix.
- 150 Time corresponding to 15 degrees of arc: Abbr.
- 151 Belt of sky centered on ecliptic.
- 152 First artificial satellite devoted entirely to X-ray astronomy.
- 153 Class of spiral galaxies whose nuclei show bright emission lines in spectra.
- 154 Doctor of the Humanities: Abbr.
- 157 Ancient constellation bordering Pavo.
- 162 ___ Cygni, typical "dwarf nova": astronomical designation.
- 165 Configuration of celestial body that is 90 degrees of celestial longitude away from another.
- 166 Lunar mountain range.
- 169 Former large southern constellation, now subdivided into Carina, Puppis, and Vela: 2 words.
- 170 Location of most luminous star known (by absolute magnitude).
- 171 Main constituent of primary cosmic-ray particles.
- 173 Winner of 1918 Nobel Prize in Physics for his ideas regarding 165 Across.
- 174 Formal assembly.

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- 175 Earliest Greek school of scientists (6th to 5th centuries B.C.).
- 178 Institute of Home Economics: Abbr.
- 179 Element whose oxide bands typify stars with M-type spectra: Symbol.
- 181 3.1415926536: mathematical constant.
- 182 ___ star: First star found to have a companion of planetary mass.
- 186 Constellation adjacent to Pisces: Abbr.
- 188 English title of nobility.
- 191 Depth of curve at center of paraboloidal mirror.
- 193 The argument of perihelion, the orbital element describing the orientation of a celestial body's orbit in its plane: astronomical designation.
- 195 Make an offer.
- 197 Accumulation of rock fragments fallen from a cliff's face.
- 198 Star which experiences a sudden, large increase in its luminosity.
- 202 Mechanical device illustrating motions of solar system.
- 203 Shape analogous to theoretical infinite, negatively-curved space.
- 206 Alternate symbol for beryllium.
- 209 Martian feature.
- 210 Point where rays of light converged by mirror or lens meet to form image.
- 211 Typical eclipsing binary star system.
- 212 Kwajalein, Bikini, and Funafuti, for example.
- 216 Observatory in Finland.
- 218 Classical name for highest Cretan mountain.
- 221 Point at which orbit of planet intersects ecliptic.
- 225 Symbol representing the null set.
- 227 Northern constellation containing M15: Abbr.
- 228 It is not permitted: Abbr.
- 229 International unit of X radiation: Abbr.
- 230 Element in alloy used by International Bureau of Weights and Measures for international kilogram: Symbol.
- 231 Behold!: Interjection.
- 232 Element 100: Symbol.
- 233 Element responsible for D line of 232 Across: Symbol.