WorldWide Telescope

worldwidetelescope.org

LIBERACT introduction/demonstration by Alyssa Goodman, Harvard

3500 years of Observing

Stonehenge, 1500 BC

Ptolemy in Alexandria, 100 AD

Observatory Tower, Lincolnshire, UK, c. 1300

Galileo, 1600

The "Scientific Revolution"

Reber's Radio Telescope, 1937

NASA/Explorer 7 (Space-based Observing) 1959

"The Internet"

Long-distance remote-control/ "robotic" telescopes 1990s

"Virtual Observatories" 21st century

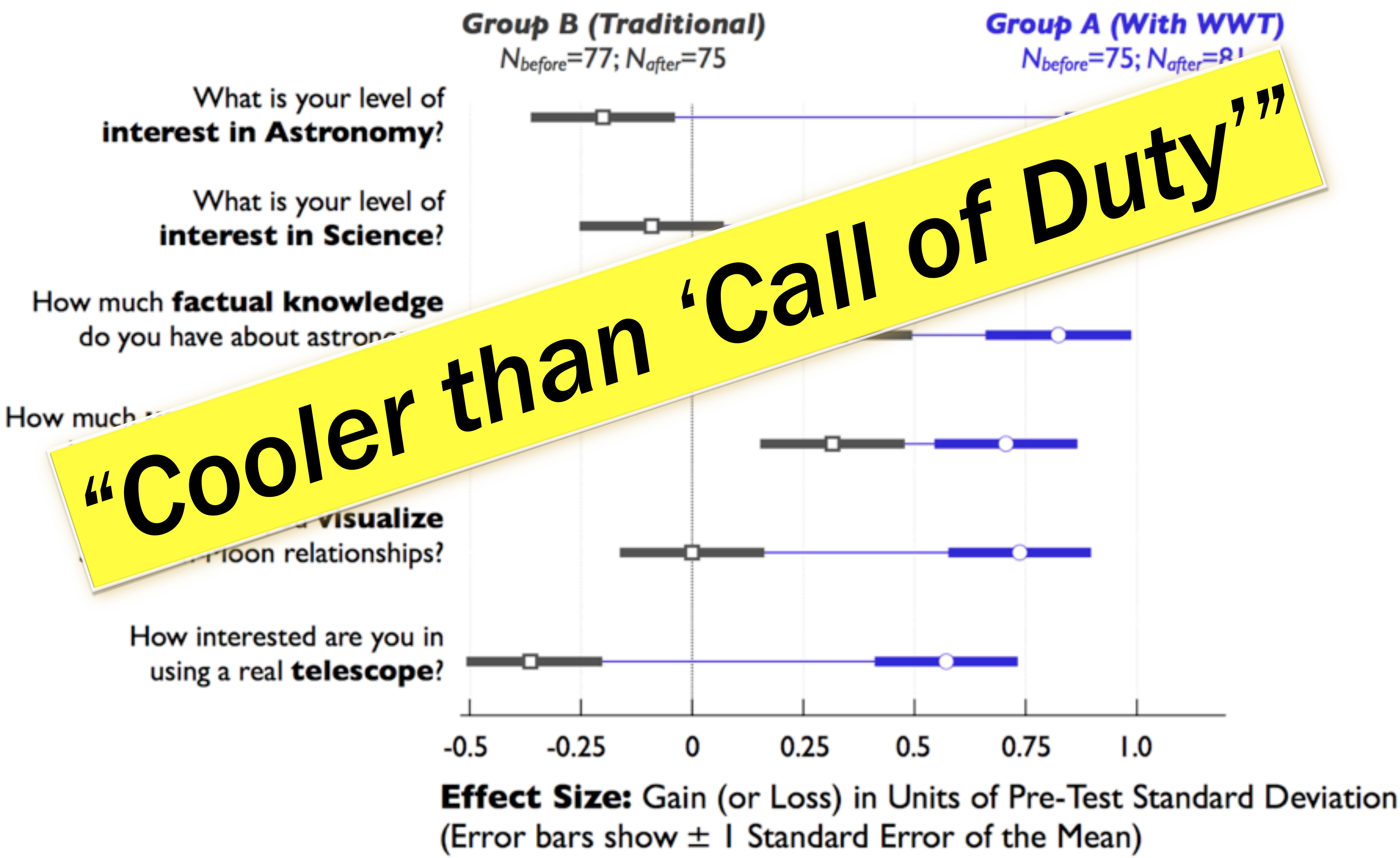
WorldWide Telescope

Curtis Wong & Jonathan Fay
Microsoft Research

Alyssa **Goodman** & Patricia **Udomprasert**
Harvard-Smithsonian Center for Astrophysics

Gains in Student Interest and Understanding

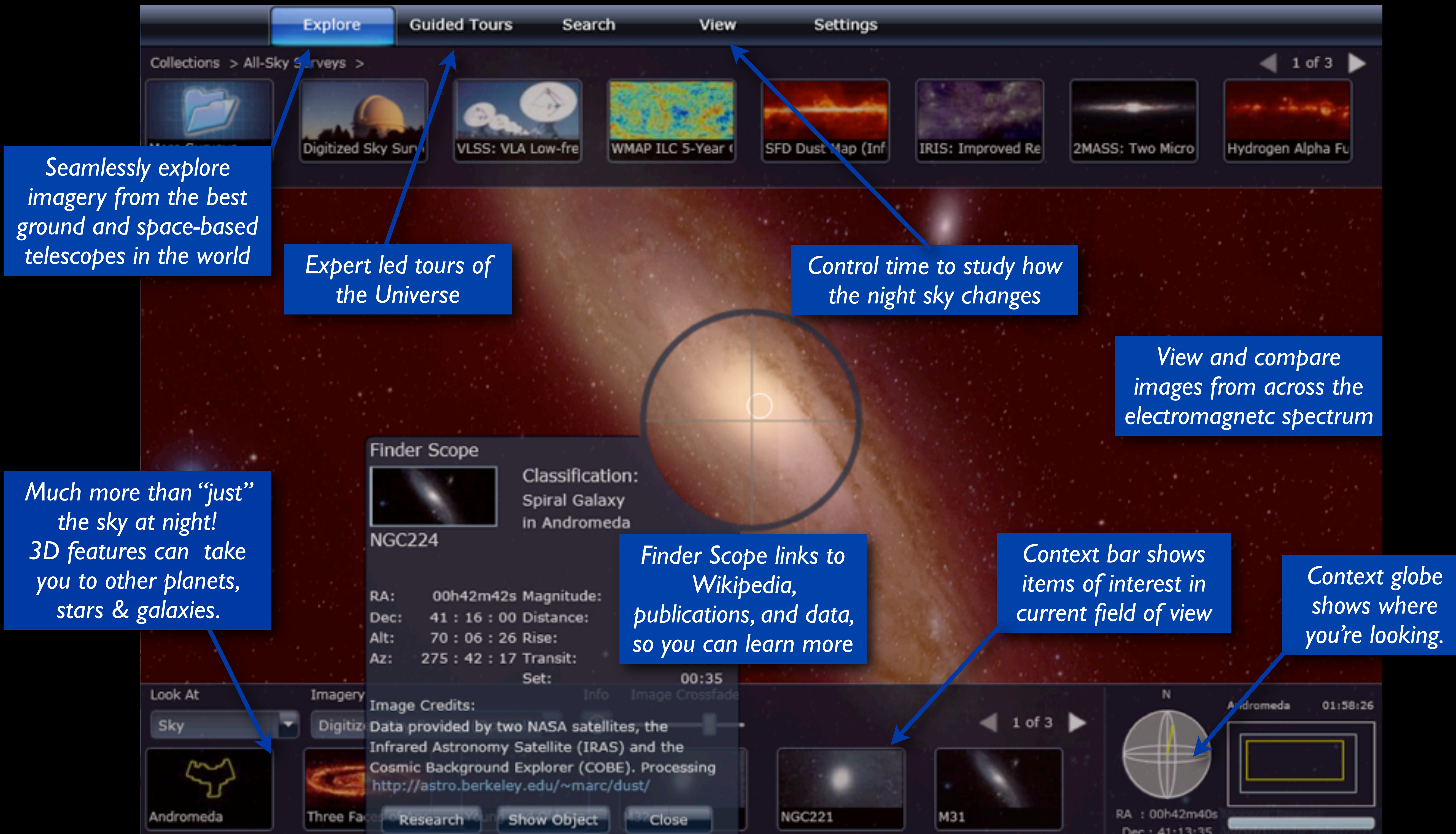
("Traditional Way" vs "WWT Way")



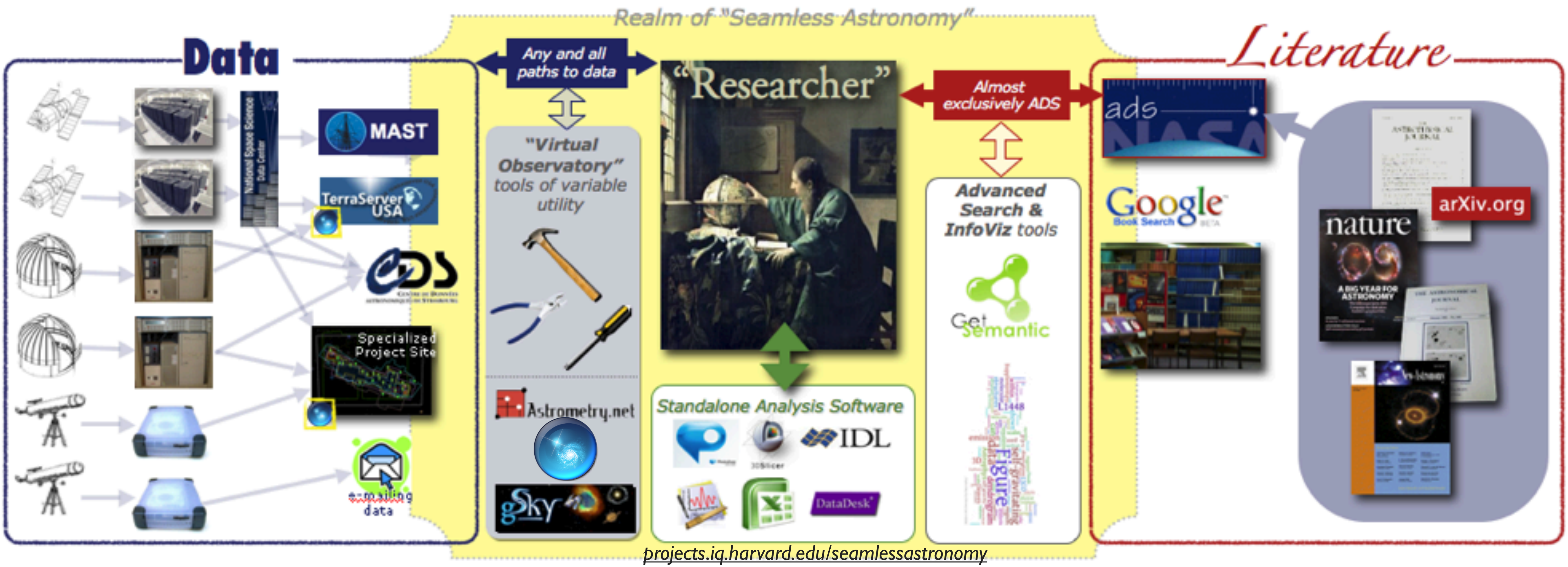
Microsoft® Research

WorldWide Telescope

worldwidetelescope.org

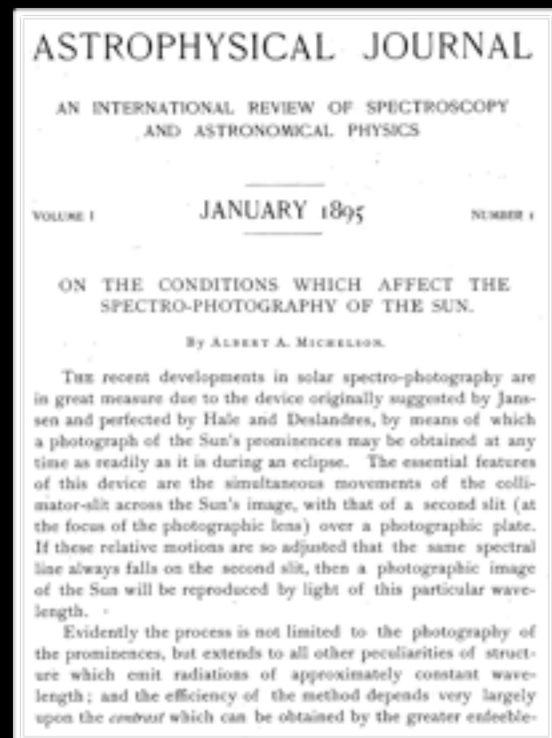


Seamless Astronomy



Alberto Accomazzi, Christopher Beaumont, Douglas Burke, Raffaele D'Abrusco, Rahul Davé, Christopher Erdmann, Pepi Fabbiano, Alyssa Goodman, Edwin Henneken, Jay Luker, Gus Muench, Michael Kurtz, Max Lu, Victoria Mittelbach, Alberto Pepe, Arnold Rots, Patricia Udomprasert (Harvard-Smithsonian CfA); Mercé Crosas (Harvard Institute for Quantitative Social Science); Christine Borgman (UCLA); Jonathan Fay & Curtis Wong (Microsoft Research); Alberto Conti (Space Telescope Science Institute)

Evolution



ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

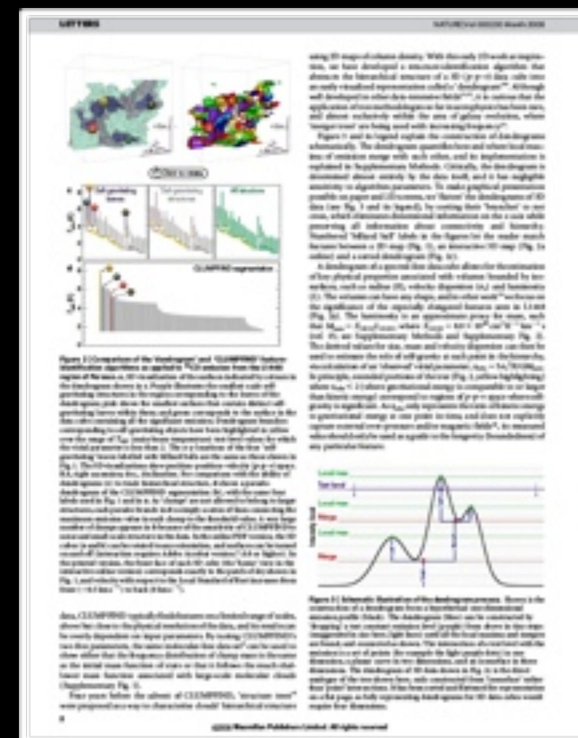
VOLUME I JANUARY 1895 NUMBER 1

ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

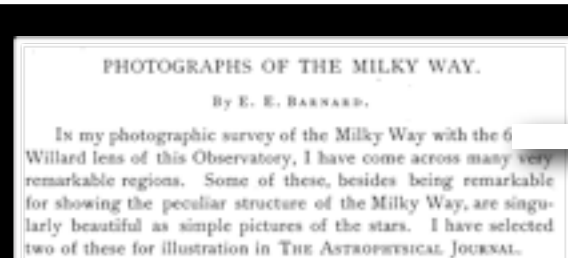
By Albert A. Michelson.

The recent developments in solar spectro-photography are in great measure due to the device originally suggested by Janssen and perfected by Hale and Deslandres, by means of which a photograph of the Sun's prominences may be obtained at any time as readily as it is during an eclipse. The essential features of this device are the simultaneous movements of the collimator-slit across the Sun's image, with that of a second slit (at the focus of the photographic lens) over a photographic plate. If these relative motions are so adjusted that the same spectral line always falls on the second slit, then a photographic image of the Sun will be reproduced by light of this particular wave-length.

Evidently the process is not limited to the photography of the prominences, but extends to all other peculiarities of structure which emit radiations of approximately constant wave-length; and the efficiency of the method depends very largely upon the *contrast* which can be obtained by the greater enfeeble-



1665 ..230 yr... 1895 ...114 yr... 2009 ...4 yr... 2013



PHOTOGRAPHS OF THE MILKY WAY.

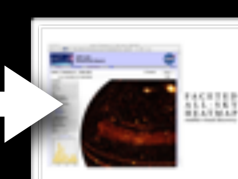
By E. E. Barnard.

In my photographic survey of the Milky Way with the 6 Willard lens of this Observatory, I have come across many very remarkable regions. Some of these, besides being remarkable for showing the peculiar structure of the Milky Way, are singularly beautiful as simple pictures of the stars. I have selected two of these for illustration in The Astrophysical Journal.

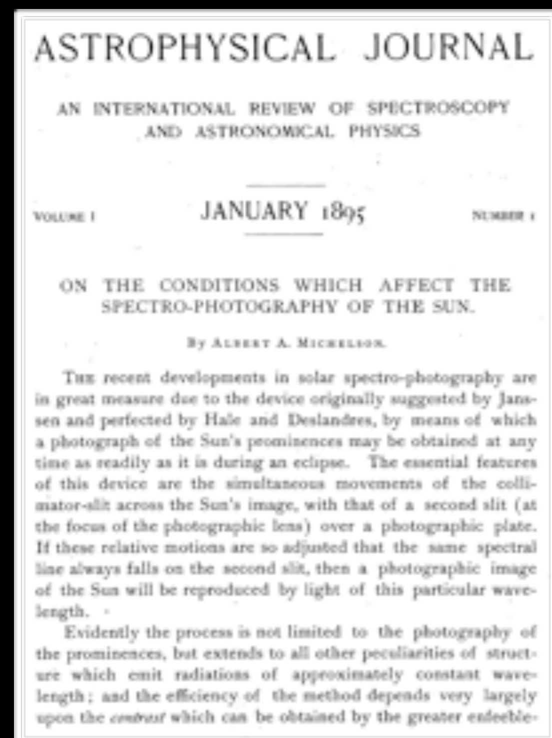
ads NASA

flickr from YAHOO!

Astrometry.net



Evolution



ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

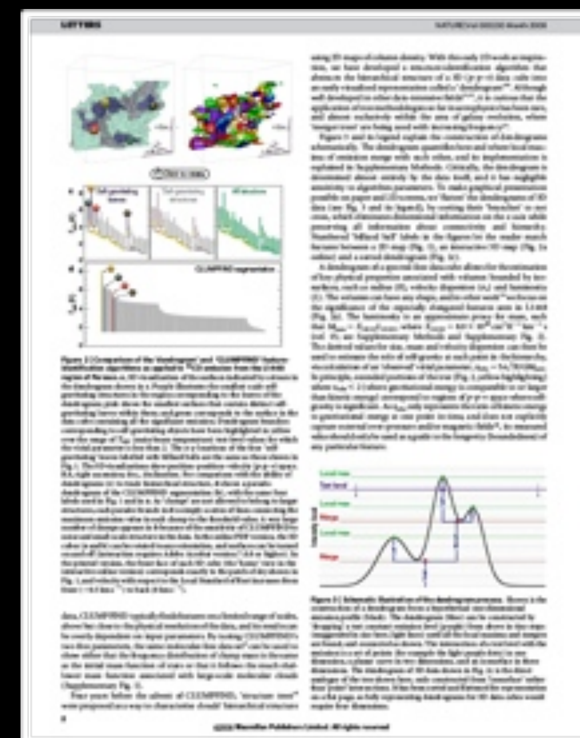
VOLUME I JANUARY 1895 NUMBER 1

ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

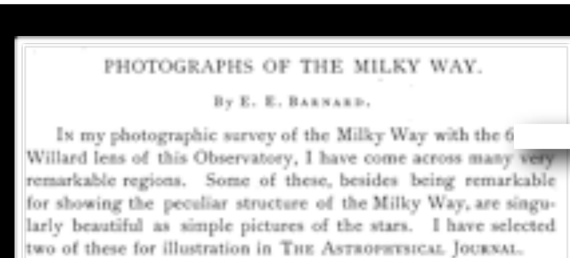
By Albert A. Michelson.

The recent developments in solar spectro-photography are in great measure due to the device originally suggested by Janssen and perfected by Hale and Deslandres, by means of which a photograph of the Sun's prominences may be obtained at any time as readily as it is during an eclipse. The essential features of this device are the simultaneous movements of the collimator-slit across the Sun's image, with that of a second slit (at the focus of the photographic lens) over a photographic plate. If these relative motions are so adjusted that the same spectral line always falls on the second slit, then a photographic image of the Sun will be reproduced by light of this particular wave-length.

Evidently the process is not limited to the photography of the prominences, but extends to all other peculiarities of structure which emit radiations of approximately constant wave-length; and the efficiency of the method depends very largely upon the *contrast* which can be obtained by the greater enfeeble-



1665 ..230 yr... 1895 ...114 yr... 2009 ...4 yr... 2013



PHOTOGRAPHS OF THE MILKY WAY.

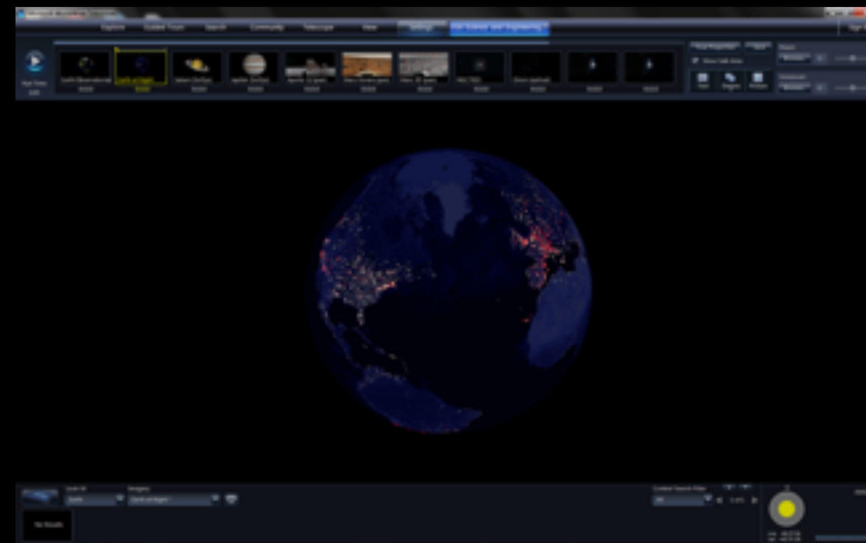
By E. E. Barnard.

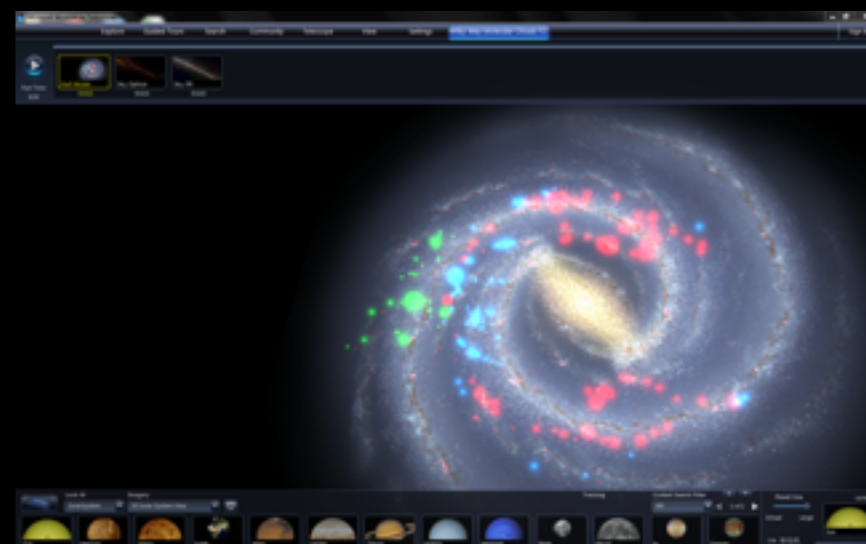
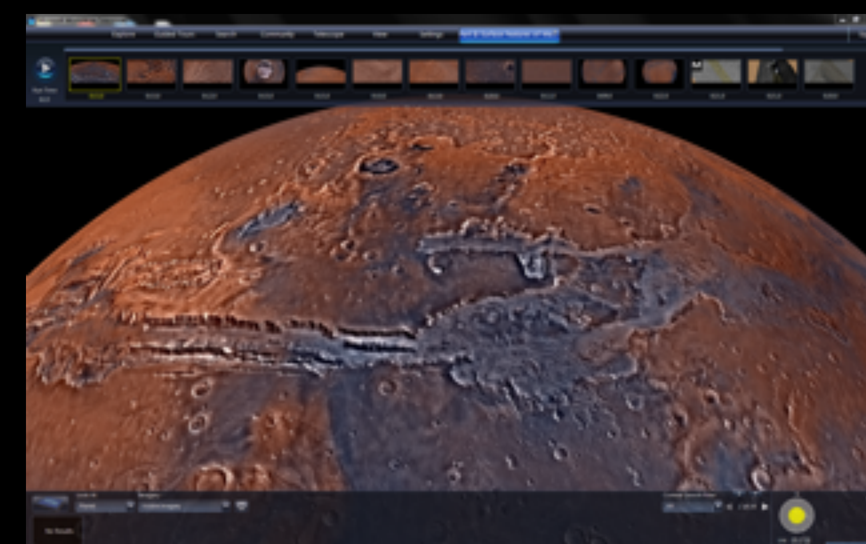
In my photographic survey of the Milky Way with the 6 Willard lens of this Observatory, I have come across many very remarkable regions. Some of these, besides being remarkable for showing the peculiar structure of the Milky Way, are singularly beautiful as simple pictures of the stars. I have selected two of these for illustration in The Astrophysical Journal.

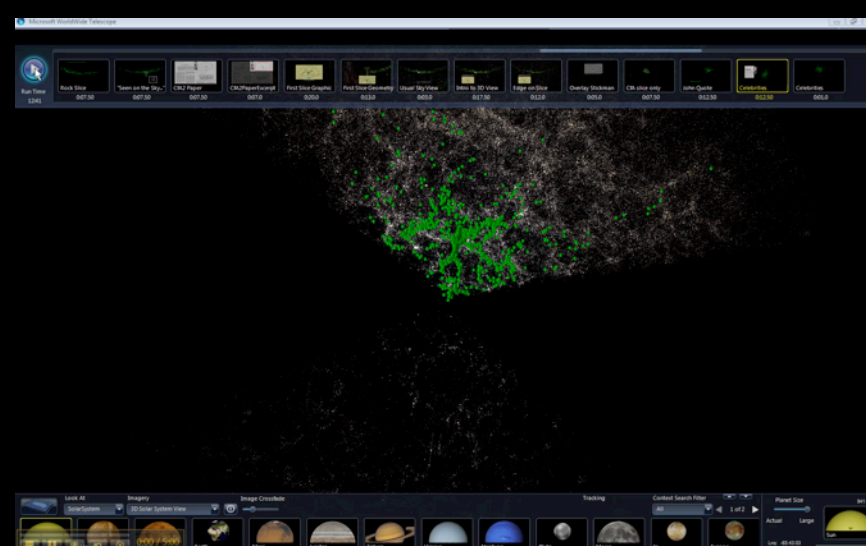
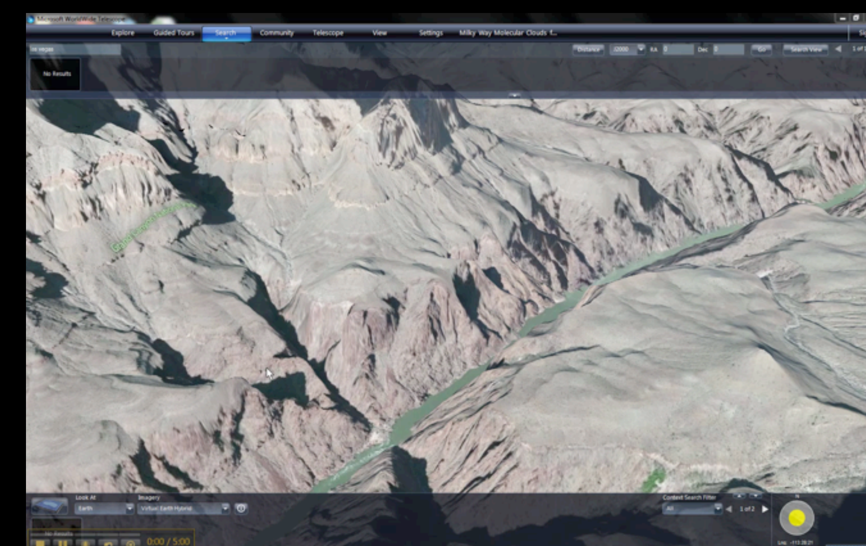
[demo]

WorldWide Telescope

worldwidetelescope.org

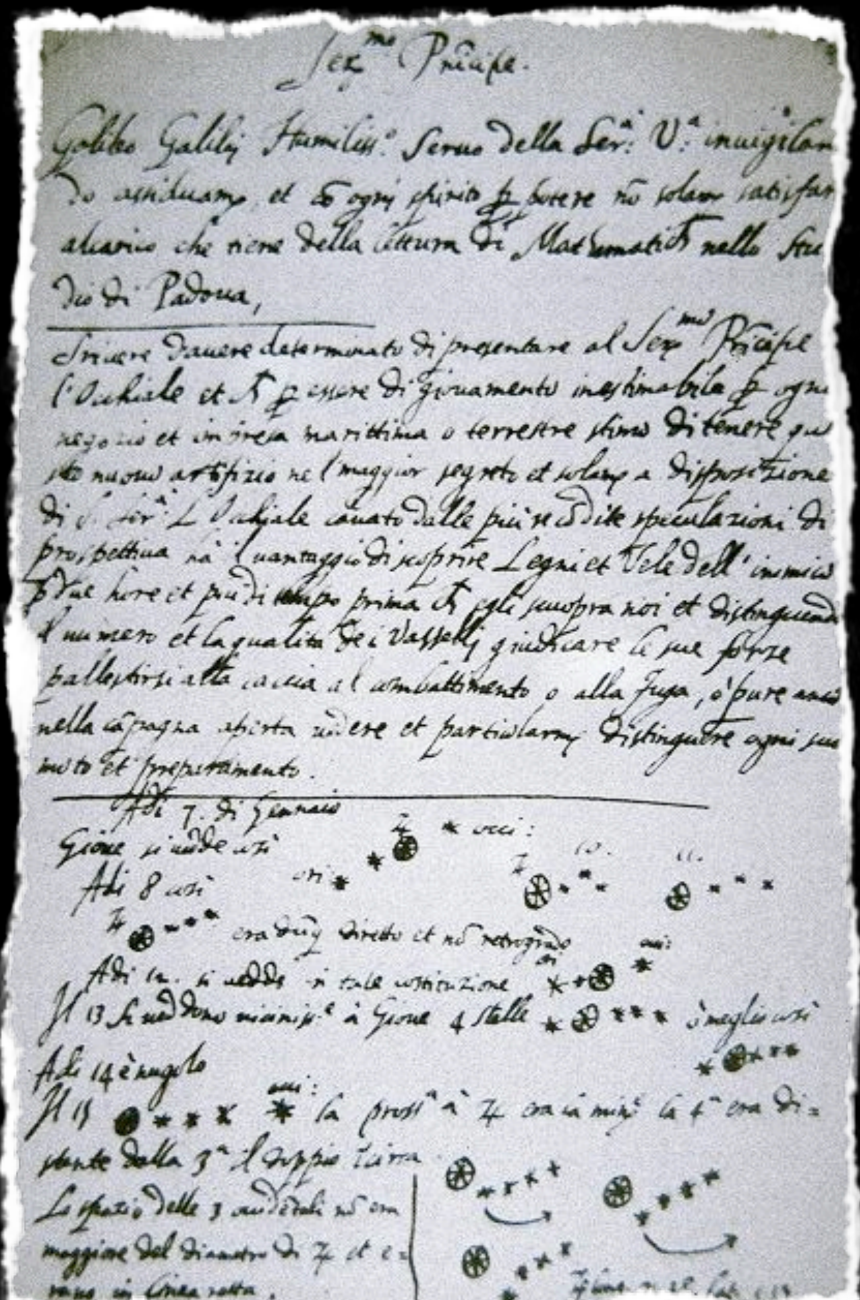



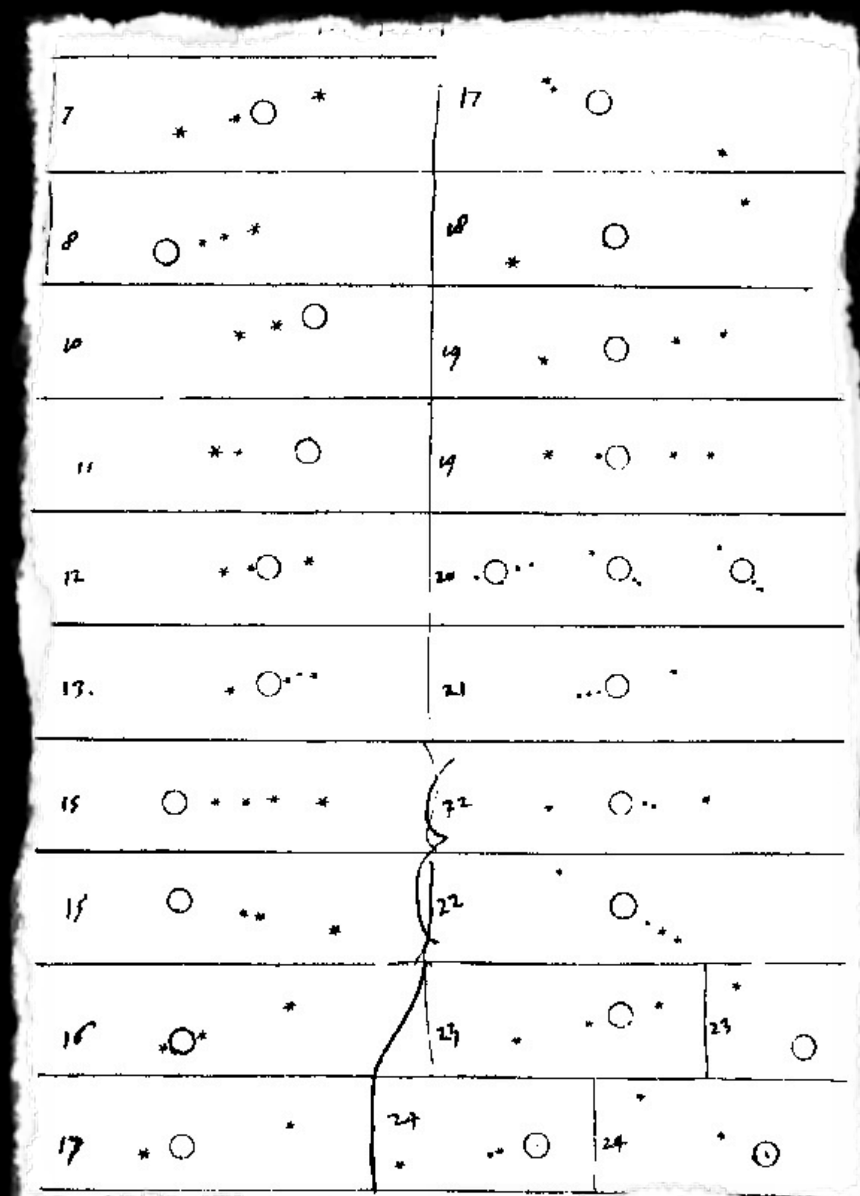




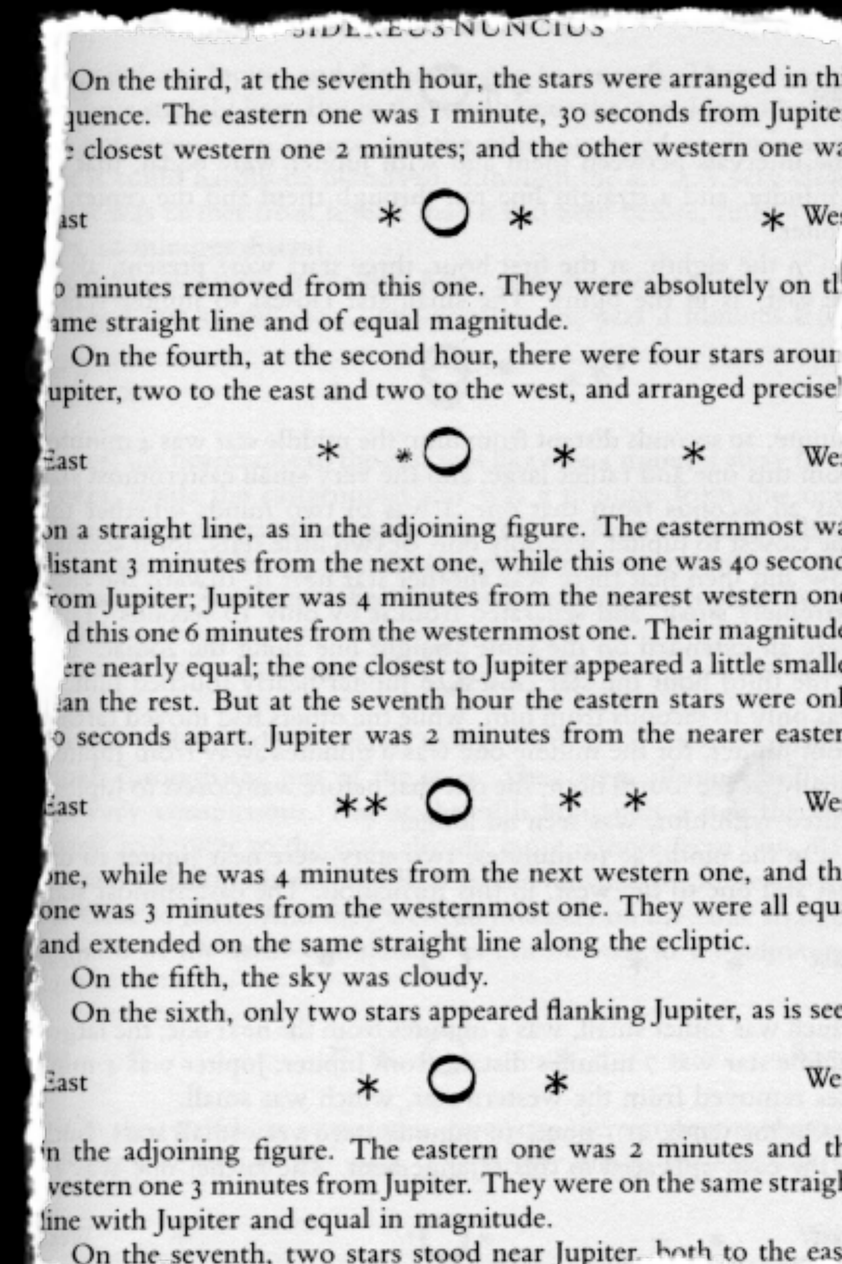



Galileo Galilei

(1564-1642)






SIDEREUS NUNCIUS

On the third, at the seventh hour, the stars were arranged in this
quence. The eastern one was 1 minute, 30 seconds from Jupiter
closest western one 2 minutes; and the other western one wa

ast * ◯ * * Wes

0 minutes removed from this one. They were absolutely on th
ame straight line and of equal magnitude.
On the fourth, at the second hour, there were four stars aroun
upiter, two to the east and two to the west, and arranged precise

East * * ◯ * * Wes

on a straight line, as in the adjoining figure. The easternmost wa
listant 3 minutes from the next one, while this one was 40 second
rom Jupiter; Jupiter was 4 minutes from the nearest western one
d this one 6 minutes from the westernmost one. Their magnitude
ere nearly equal; the one closest to Jupiter appeared a little smalle
an the rest. But at the seventh hour the eastern stars were only
0 seconds apart. Jupiter was 2 minutes from the nearer easter

East ** ◯ * * West

ne, while he was 4 minutes from the next western one, and this
one was 3 minutes from the westernmost one. They were all equal
and extended on the same straight line along the ecliptic.
On the fifth, the sky was cloudy.
On the sixth, only two stars appeared flanking Jupiter, as is seen

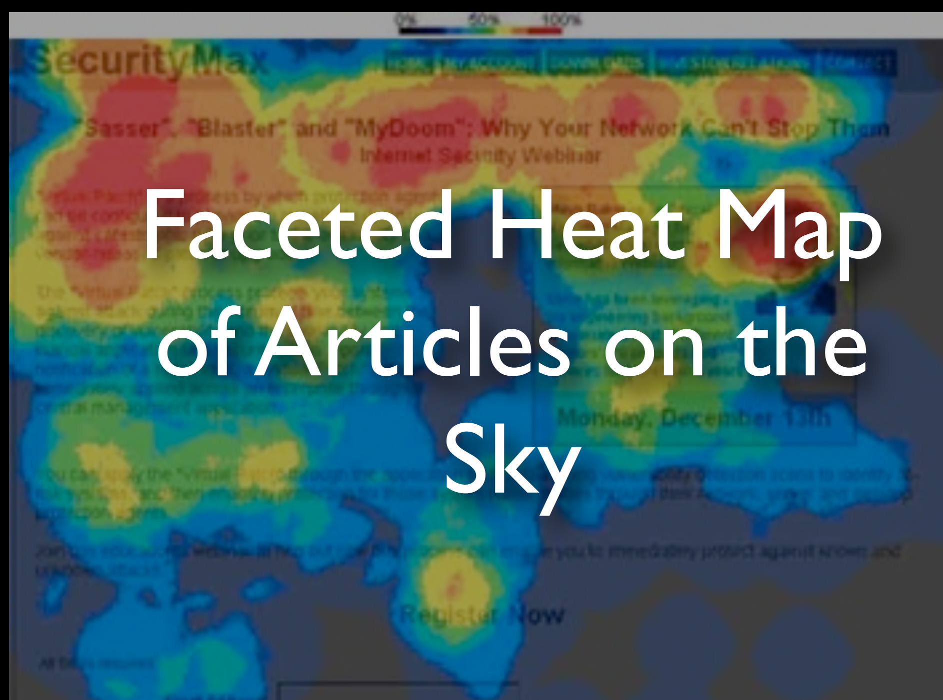
East * ◯ * West

n the adjoining figure. The eastern one was 2 minutes and the
western one 3 minutes from Jupiter. They were on the same straight
line with Jupiter and equal in magnitude.
On the seventh, two stars stood near Jupiter, both to the east

Notes for & re-productions of Siderius Nuncius

[demo]

Seamless Astronomy: ADS All Sky Survey



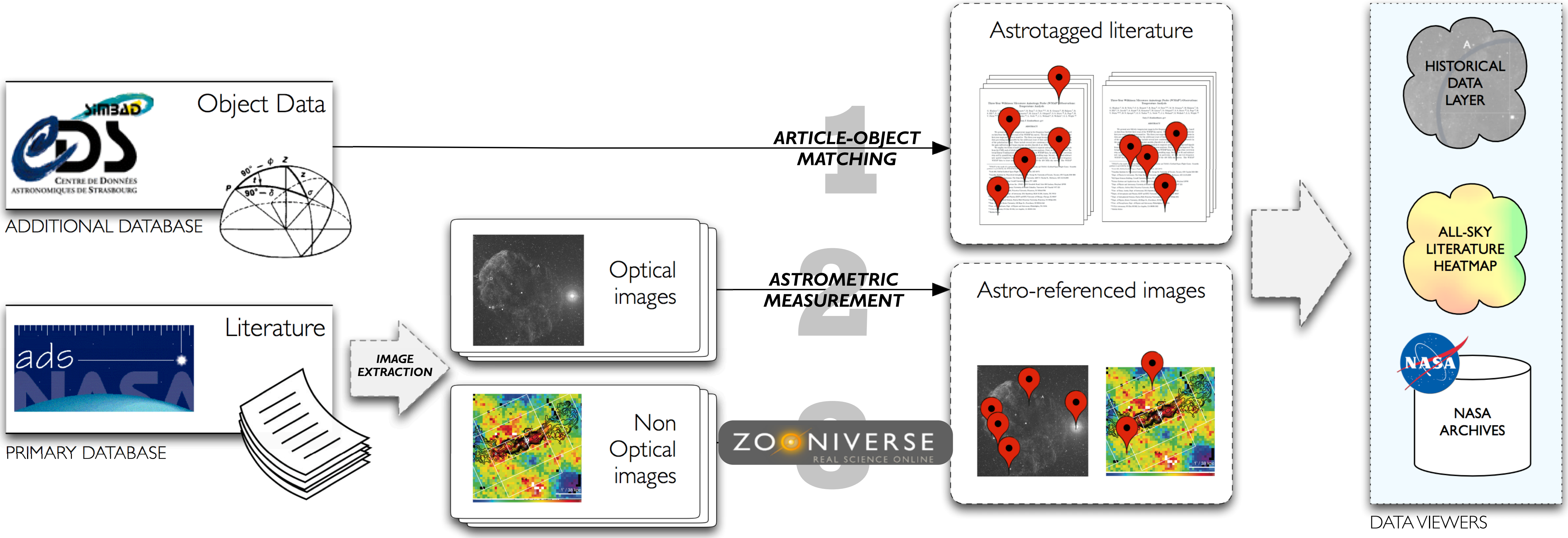
Faceted Heat Map of Articles on the Sky

ADS-CDS-Seamless-MSR collaboration

Historical Image Layer Extracted from ALL ADS holdings (astrometry.net & Zooniverse)

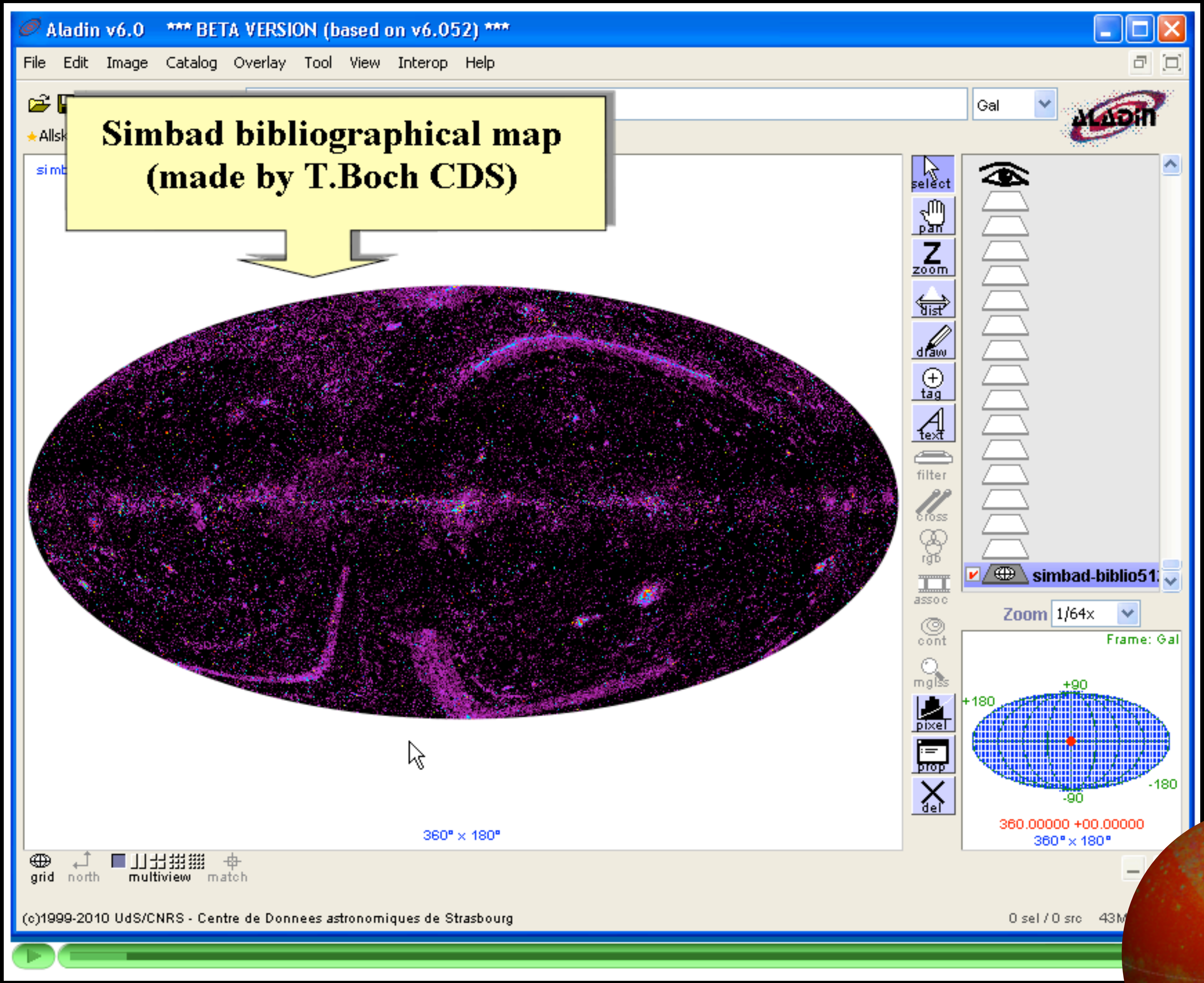
ADS-Seamless-astrometry.net-MSR-Zooniverse collaboration

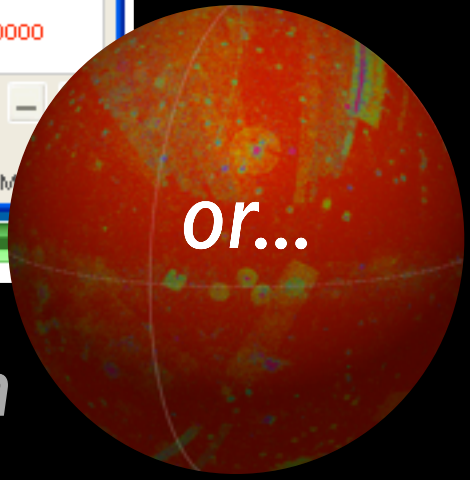
Seamless Astronomy: ADS All Sky Survey



slide courtesy of Alberto Pepe

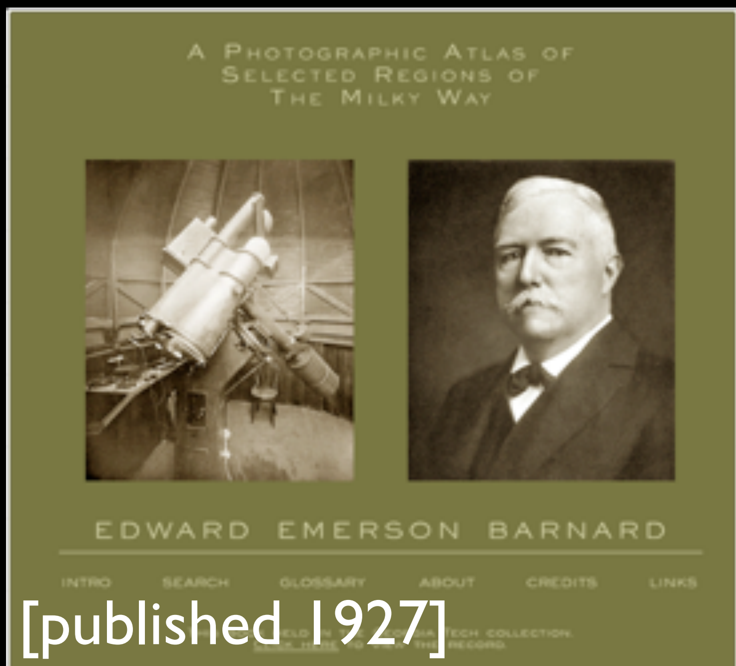
Prototype of Articles on the Sky (2010)



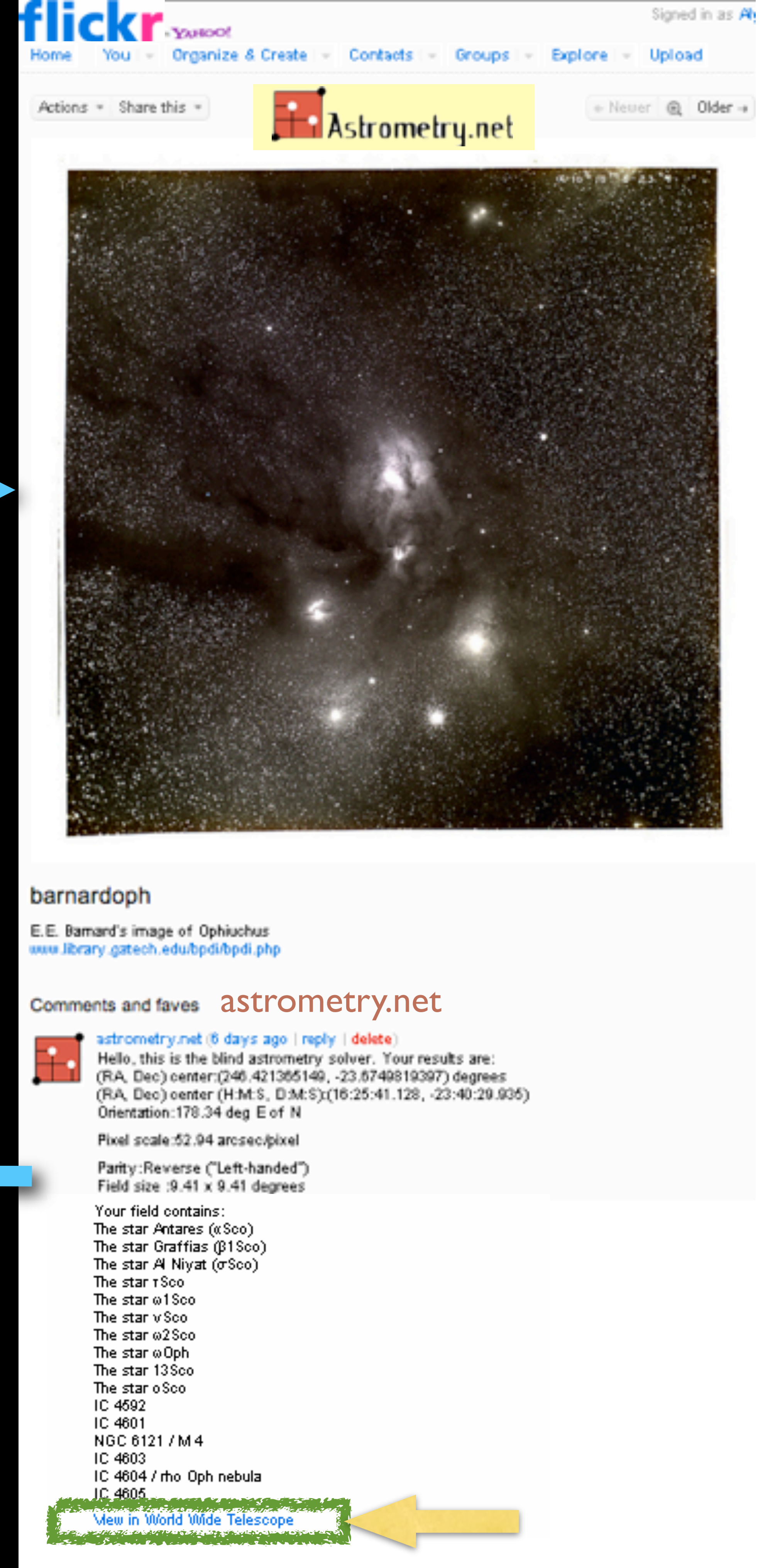


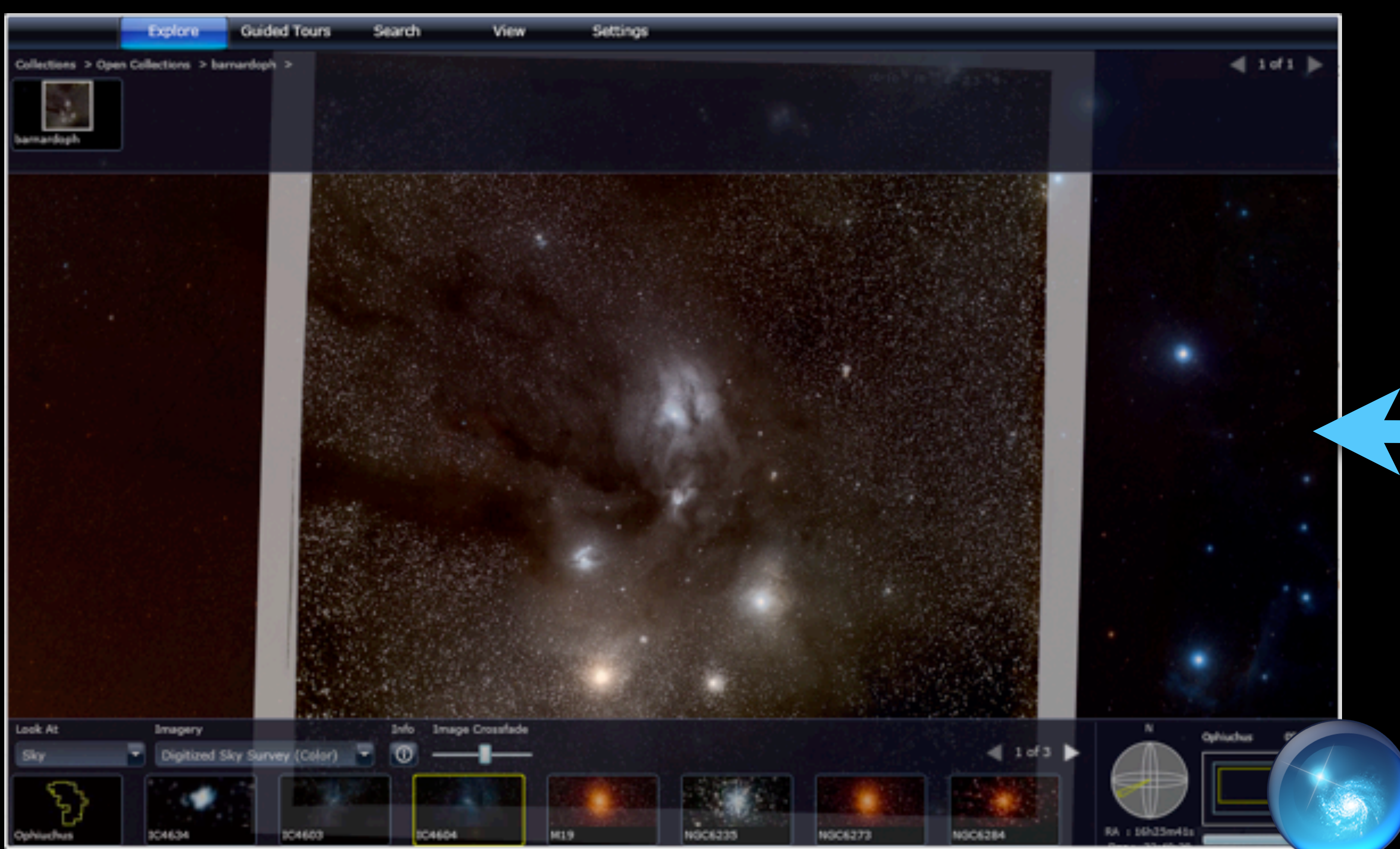
with thanks to CDS/Pierre Fernique/Thomas Boch

Reviving "Dead" Data



[published 1927]





>1 Million Articles, like this one

DRAFT VERSION OCTOBER 18, 2010
Preprint typeset using LaTeX style emulateapj v. 11/10/09

INVESTIGATING THE COSMIC-RAY IONIZATION RATE NEAR THE SUPERNOVA REMNANT IC 443 THROUGH H_3^+ OBSERVATIONS[1,2]

NICK INDRIOLO[3], GEOFFREY A. BLAKE[4], MIWA GOTO[5], TOMONORI USUDA[6], TAKESHI OKA[7], T. R. GEBALLE[8], BRIAN D. FIELDS[3,9] BENJAMIN J. MCCALL[3,9,10]

Draft version October 18, 2010

ABSTRACT

Observational and theoretical evidence suggests that high-energy Galactic cosmic rays are primarily accelerated by supernova remnants. If also true for low-energy cosmic rays, the ionization rate near a supernova remnant should be higher than in the general Galactic interstellar medium (ISM). We have searched for H_3^+ absorption features in 6 sight lines which pass through molecular material near IC 443—a well-studied case of a supernova remnant interacting with its surrounding molecular material—for the purpose of inferring the cosmic-ray ionization rate in the region. In 2 of the sight lines (toward ALS 8828 and HD 254577) we find large H_3^+ column densities, $N(H_3^+) \approx 3 \times 10^{14}$ cm^{-2}, and deduce ionization rates of $\zeta_2 \approx 2 \times 10^{-15}$ s^{-1}, about 5 times larger than inferred toward average diffuse molecular cloud sight lines. However, the 3σ upper limits found for the other 4 sight lines are consistent with typical Galactic values. This wide range of ionization rates is likely the result of particle acceleration and propagation effects, which predict that the cosmic-ray spectrum and thus ionization rate should vary in and around the remnant. While we cannot determine if the H_3^+ absorption arises in post-shock (interior) or pre-shock (exterior) gas, the large inferred ionization rates suggest that IC 443 is in fact accelerating a large population of low-energy cosmic rays. Still, it is unclear whether this population can propagate far enough into the ISM to account for the ionization rate inferred in diffuse Galactic sight lines.

Subject headings: astrochemistry – cosmic rays – ISM: supernova remnants

1. INTRODUCTION

As cosmic rays propagate through the interstellar medium (ISM) they interact with the ambient material. These interactions include excitation and ionization of atoms and molecules, spallation of nuclei, excitation of nuclear states, and the production of neutral pions (π^0) which decay into gamma-rays. Evidence suggests that Galactic cosmic rays are primarily accelerated by supernova remnants (SNRs) through the process of diffusive shock acceleration (e.g. Drury 1983; Blandford & Eichler 1987), so interstellar clouds in close proximity to an SNR should provide a prime "laboratory" for studying these interactions. IC 443 represents such a case, as portions of the SNR shock are known to be interacting with the neighboring molecular clouds.

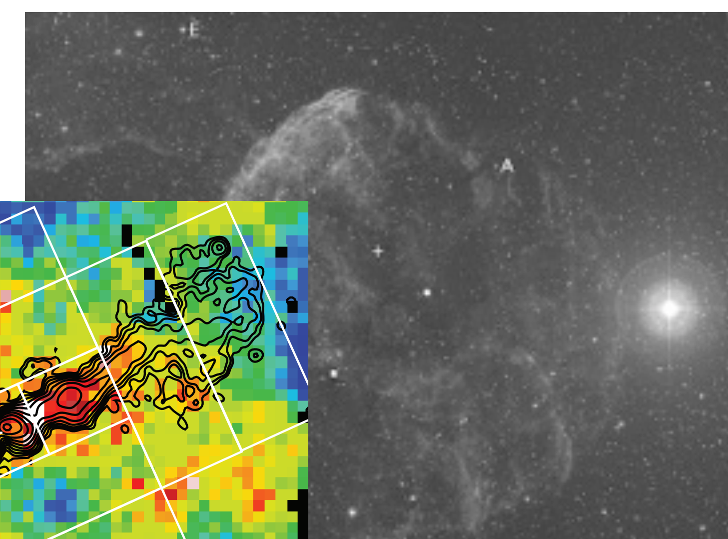
IC 443 is an intermediate age remnant (about 30,000 yr; Chevalier 1999) located in the Galactic anti-center region $(l, b) \approx (189°, +3°)$ at a distance of about 1.5 kpc in the Gem OB1 association (Welsh & Sallmen 2003), and is a particularly well-studied SNR. Figure 1 shows the red image of IC 443 taken during the Second Palomar Observatory Sky Survey. The remnant is composed of subshells A and B; shell A is to the NE—its center at $\alpha = 06^h17^m08.4^s$, $\delta = +22°36'39.4''$ J2000.0 is marked by the cross—while shell B is to the SW. Adopting a distance of 1.5 kpc, the radii of subshells A and B are about 7 pc and 11 pc, respectively. Between the subshells is a darker lane that runs across the remnant from the NW to SE. This is a molecular cloud which has been mapped in ^{12}CO emission (Cornett et al. 1977; Dickman et al. 1992; Zhang et al. 2009), and is known to be in the foreground because it absorbs X-rays emitted by the hot remnant interior (Troja et al. 2006). Aside from this quiescent foreground cloud, observations of the $J = 1 \rightarrow 0$ line of ^{12}CO also show shocked molecular material coincident with IC 443 (DeNoyer 1979; Huang et al. 1986; Dickman et al. 1992; Wang & Scoville 1992). These shocked molecular clumps first identified by DeNoyer (1979) and Huang et al. (1986) in CO have also been observed in several atomic and small molecular species (e.g. White et al. 1987; Burton et al. 1988; van Dishoeck et al. 1993; White 1994; Snell et al. 2005), and are thought to be the result of the expanding SNR interacting with the surrounding ISM. While many of the shocked clumps are coincident with the quiescent gas, it

[1] Some of the data presented herein were obtained at the W.M. Keck Observatory, which is operated as a scientific partnership among the California Institute of Technology, the University of California and the National Aeronautics and Space Administration. The Observatory was made possible by the generous financial support of the W.M. Keck Foundation.
[2] Based in part on data collected at Subaru Telescope, which is operated by the National Astronomical Observatory of Japan.
[3] Department of Astronomy, University of Illinois at Urbana-Champaign, Urbana, IL 61801
[4] Division of Geological and Planetary Sciences and Division of Chemistry and Chemical Engineering, MS 150-21, California Institute of Technology, Pasadena, CA 91125
[5] Max-Planck-Institut für Astronomie, Königstuhl 17, Heidelberg D-69117, Germany
[6] Subaru Telescope, 650 North A'ohoku Place, Hilo, HI 96720
[7] Department of Astronomy and Astrophysics and Department of Chemistry, University of Chicago, Chicago, IL 60637
[8] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720
[9] Department of Physics, University of Illinois at Urbana-Champaign, Urbana, IL 61801
[10] Department of Chemistry, University of Illinois at Urbana-Champaign, Urbana, IL 61801

Table 1
Candidate New and Extended Outflow Locations

[illegible]	[illegible]	[illegible]	[illegible]	Mass ($M_\odot$)	Momentum ($M_\odot$ km s^{-1})	Kinetic Energy (10^{42} erg)	Driving Source Candidate(s)
[illegible]	[illegible]	[illegible]	[illegible]	0.05	0.19	6.93	L1448-IRS1
CPOC 2	[illegible]	[illegible]	[illegible]	0.36	0.88	21.68	L1448-IRS1
CPOC 3	03:24:30	30:50:00	10 × 5	0.02	0.08	2.93	L1448-IRS3
CPOC 4	03:24:54	30:43:10	4 × 4	0.01	0.04	2.10	Multiple in L1448
CPOC 5	03:25:39	30:28:20	7 × 5	0.02	0.05	1.32	SSTc2dJ032519.52+303424.2
CPOC 6	03:27:55	31:19:50	4 × 3	0.02	0.03	0.36	Multiple NGC 1333, near HH 338
CPOC 7	03:28:00	31:03:40	15 × 12	0.29	1.79	112.00	SSTc2dJ032834.49+310051.1
CPOC 8	03:28:32	30:28:20	8 × 11	0.11	0.28	7.17	Near HH 750 and HH 743, SSTc2dJ032835.03+302009.9 or SSTc2dJ032906.05+303039.2
CPOC 9	03:28:28	31:13:20	8 × 8	0.26	0.56	12.63	SSTc2dJ032832.56+311105.1 or SSTc2dJ032837.09+311330.8
CPOC 10	03:28:27	31:23:20	8 × 8	0.24	0.42	7.50	SSTc2dJ032844.09+312052.7
CPOC 11	03:28:40	31:07:10	8 × 6	0.11	0.27	7.01	STTc2dJ032834.53+310705.5
CPOC 12	03:28:43	31:07:30	8 × 7	0.19	0.97	52.02	SSTc2dJ032843.24+311042.7
CPOC 13	03:28:50	31:27:10	6 × 8	0.31	0.80	21.00	Multiple in NGC 1333
CPOC 14	03:28:57	30:50:20	6 × 5	0.03	0.05	0.73	SSTc2dJ032850.62+304244.7 or SSTc2dJ032852.17+304505.5
CPOC 15	03:29:07	30:45:50	7 × 5	0.19	0.80	32.82	SSTc2dJ032850.62+304244.7 or SSTc2dJ032852.17+304505.5
CPOC 16	03:29:30	31:07:10	6 × 6	0.04	0.10	2.40	HH 18A, multiple in NGC 1333
CPOC 17	03:29:41	31:17:30	9 × 13	3.20	8.49	235.28	Near HH 497, HH 336, multiple in NGC 1333
CPOC 18	03:29:41	31:27:10	5 × 6	0.08	0.21	6.35	HH 764, multiple in NGC 1333
CPOC 19	03:29:27	31:34:00	9 × 7	0.19	0.59	19.31	IRAS 03262+3123
CPOC 20	03:30:06	31:27:10	5 × 4	0.04	0.08	1.73	Multiple NGC 1333
CPOC 21	03:30:11	31:14:00	8 × 5	0.05	0.13	3.45	HH 767, SSTc2dJ033024.08+311404.4

N	Identifier	Otype	ICRS (J2000) RA	ICRS (J2000) DEC	Sp type	#ref 1850 - 2011	#notes
1	* zet Per	V*	03 54 07.9215	+31 53 01.088	B1Ib	706	1
2	CCDM J03554+3103A	**	03 55 23.0773	+31 02 45.014	O9.5IIIe-B0Ve	720	0
3	NAME ELNATH	*i*	05 26 17.5134	+28 36 26.820	B7III	287	1
4	* zet Tau	Be*	05 37 38.6858	+21 08 33.177	B2IV	592	0
5	Ass Gem OB 1-	As*	06 09.8	+21 35	~	118	0
6	TYC 1877-287-1	*	06 16 13.3409	+22 45 48.634	sdO	9	0
7	HD 254577	*	06 17 54.3853	+22 24 32.928	B0.5II-III	30	0
8	HD 43582	V*	06 18 00.3459	+22 39 29.995	B0IIIn	21	0
9	IC 443	SNR	06 18 02.7	+22 39 36	S	729	2
10	HD 254755	*	06 18 31.7741	+22 40 45.125	O9Vp	33	0



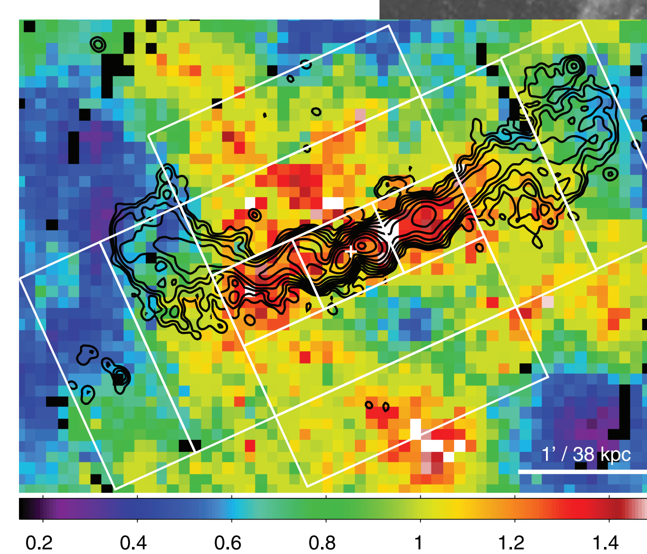


Figure 3. Abundance map of the core of AWM 4, with GMRT 610-MI contours overlaid. Rectangular regions were used to examine the variati in abundance across and along the jet. The white cross marks the positi of the radio core.