DISCOVERY OF A GAS-RICH COMPANION TO THE EXTREMELY METAL-POOR GALAXY DDO 68

Published version:
DOI: 10.1088/2041-8205/787/1/L1

The Astrophysical Journal Letters, 787:L1 (7pp), 2014 May 20 doi:10.1088/2041-8205/787/1/L1

DISCOVERY OF A GAS-RICH COMPANION TO THE EXTREMELY METAL-POOR GALAXY DDO 68

John M. Cannon[1], Megan Johnson[2], Kristen B. W. McQuinn[3], Erik D. Alfvin[1], Jeremy Bailin[4], H. Alyson Ford[5], Léo Girardi[6], Alec S. Hirschauer[7], Steven Janowiecki[7], John J. Salzer[7], Angela Van Sistine[7], Andrew Dolphin[8], E. C. Elson[9], Baerbel Koribalski[2], Paola Marigo[10], Jessica L. Rosenberg[11], Philip Rosenfield[10], Evan D. Skillman[3], Aparna Venkatesan[12], and Steven R. Warren[13]

[1] Department of Physics and Astronomy, Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105, USA; jcannon@macalester.edu
[2] Australia Telescope National Facility, CSIRO Astronomy and Space Science, P.O. Box 76, NSW 1710, Epping, Australia
[3] Minnesota Institute for Astrophysics, University of Minnesota, Minneapolis, MN 55455, USA
[4] Department of Physics and Astronomy, University of Alabama, P.O. Box 870324, Tuscaloosa, AL 35487-0324, USA
[5] National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944, USA
[6] Osservatorio Astronomico di Padova—INAF, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy
[7] Department of Astronomy, Indiana University, 727 East Third Street, Bloomington, IN 47405, USA
[8] Raytheon Company, 1151 E. Hermans Road, Tucson, AZ 85756, USA
[9] Astrophysics, Cosmology and Gravity Centre (ACGC), Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[10] Dipartimento di Fisica e Astronomia Galileo Galilei, Universitá degli Studi di Padova, Vicolo dell'Osservatorio 3, I-35122 Padova, Italy
[11] School of Physics, Astronomy, and Computational Science, George Mason University, Fairfax, VA 22030, USA
[12] Department of Physics and Astronomy, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117, USA
[13] Department of Astronomy, University of Maryland, CSS Bldg., Rm. 1024, Stadium Drive, College Park, MD 20742-2421, USA
Received 2014 March 29; accepted 2014 April 11; published 2014 April 25

ABSTRACT

We present H I spectral-line imaging of the extremely metal-poor galaxy DDO 68. This system has a nebular oxygen abundance of only ∼3% $Z_\odot$, making it one of the most metal-deficient galaxies known in the local volume. Surprisingly, DDO 68 is a relatively massive and luminous galaxy for its metal content, making it a significant outlier in the mass–metallicity and luminosity–metallicity relationships. The origin of such a low oxygen abundance in DDO 68 presents a challenge for models of the chemical evolution of galaxies. One possible solution to this problem is the infall of pristine neutral gas, potentially initiated during a gravitational interaction. Using archival H I spectral-line imaging obtained with the Karl G. Jansky Very Large Array, we have discovered a previously unknown companion of DDO 68. This low-mass ($M_{\rm H\,I} = 2.8 \times 10^7\,M_\odot$), recently star-forming ($\mathrm{SFR_{FUV}} = 1.4 \times 10^{-3} M_\odot\ \mathrm{yr}^{-1}$, $\mathrm{SFR_{H\alpha}} < 7 \times 10^{-5} M_\odot\ \mathrm{yr}^{-1}$) companion has the same systemic velocity as DDO 68 ($V_{\rm sys} = 506$ km s^{-1}; $D = 12.74 \pm 0.27$ Mpc) and is located at a projected distance of ∼42 kpc. New H I maps obtained with the 100 m Robert C. Byrd Green Bank Telescope provide evidence that DDO 68 and this companion are gravitationally interacting at the present time. Low surface brightness H I gas forms a bridge between these objects.

Key words: galaxies: dwarf – galaxies: evolution – galaxies: individual (DDO 68, DDO 68 C) – galaxies: irregular
Online-only material: color figures

1. INTRODUCTION

The most metal-poor galaxies in the local universe provide important constraints on models of galaxy evolution. To date the lowest measured nebular oxygen abundance in a star-forming galaxy is 3% of the solar value. Four known galaxies have this abundance value: the starburst galaxy SBS 0335−052W (Izotov et al. 2005), the BCD galaxy I Zw 18 (Skillman & Kennicutt 1993), the dwarf galaxy Leo P (Skillman et al. 2013), and the subject of this Letter, DDO 68 (Pustilnik et al. 2005).

While the extremely low oxygen abundance of DDO 68 makes it an interesting system, its other physical characteristics make it a critical test bed for our understanding of the chemical evolution of galaxies. Specifically, DDO 68 is an outlier on the mass–metallicity (*M*–*Z*) relationship (Pustilnik et al. 2005; Berg et al. 2012); it is overly massive compared to the other known systems with comparable metallicity. The H I mass of DDO 68 is four times larger than that of I Zw 18 (van Zee et al. 1998) and three orders of magnitude larger than that of Leo P (Bernstein-Cooper et al. 2014). The deviation of DDO 68 from the *M*–*Z* relation is so pronounced that it has been excluded from recent works attempting to calibrate this relationship at the lowest abundances (Berg et al. 2012; Skillman et al. 2013).

The presence of an extremely metal-poor interstellar medium in a massive dwarf galaxy poses a serious obstacle for models of the chemical evolution of galaxies. One possible origin for these enigmatic properties is the infall of pristine gas. As argued in Ekta & Chengalur (2010), the infall of primordial gas may produce lower metallicities and lower effective chemical yields. Based on multiple lines of evidence, this scenario may be at work in DDO 68. As the archival *Hubble Space Telescope* (*HST*) image in Figure 1(a) shows, the stellar morphology of DDO 68 is severely disturbed; an elongated stream of stars extends southward over an arcminute (>3.7 kpc) from the main stellar body. This stream is especially prominent in the *Galaxy Evolution Explorer* (*GALEX*) images shown in Figure 2. The continuum-subtracted *HST* Hα image shown in Figure 1(b) reveals widespread massive star formation (SF) in DDO 68. Curiously, most of this nebular emission is concentrated in four SF complexes in the north of the galaxy, and in one complex in the stellar stream to the south; each of these H II regions is co-spatial with high column density H I gas ($N_{\rm H\,I} > 2 \times 10^{21}$ cm^{-2}, or $\sigma_{\rm H\,I} > 16\,M_\odot$ pc^{-2}) that is significantly displaced from the center of the main stellar component of DDO 68. In agreement with the previous studies of the H I morphology and dynamics of DDO 68 by Stil & Israel (2002) and Ekta et al. (2008), we find

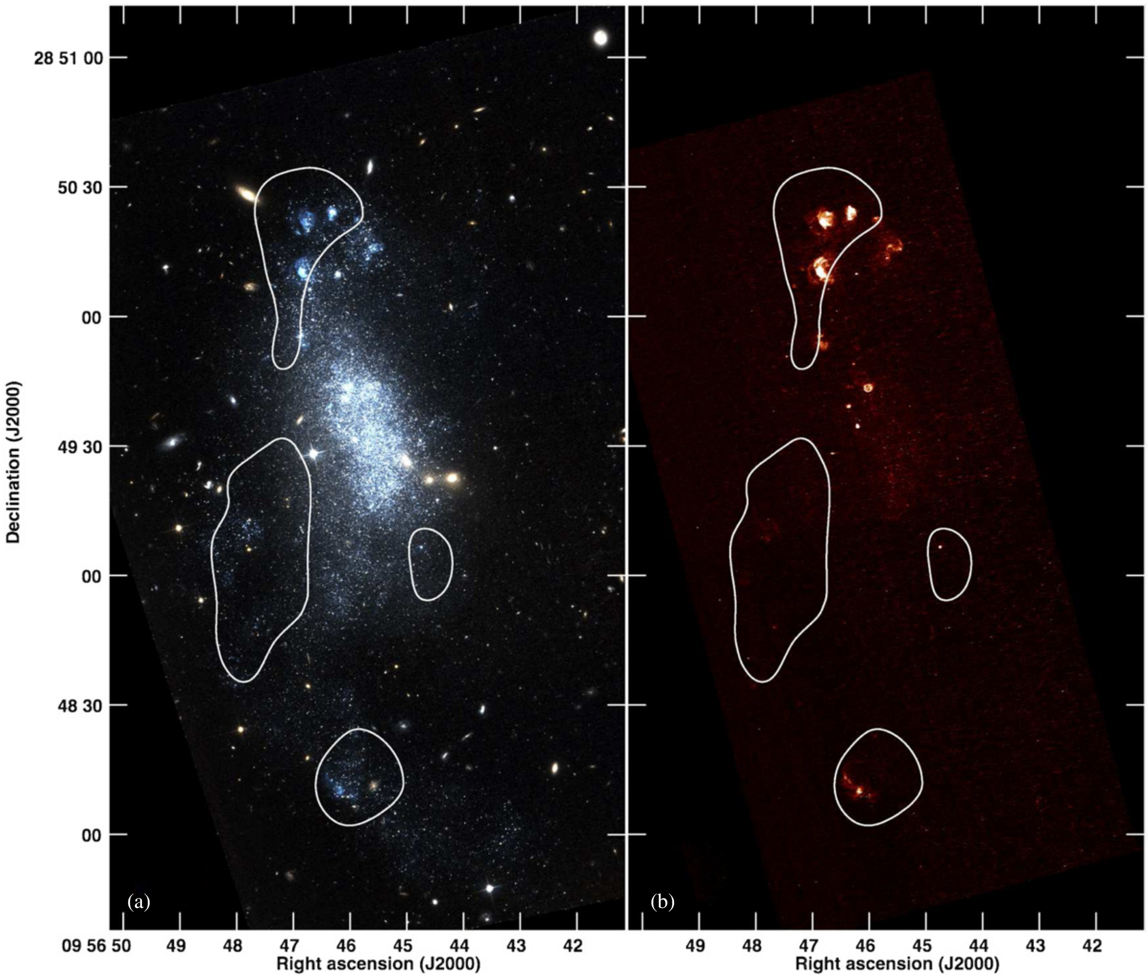

Figure 1. (a) Color *HST*/Advanced Camera for Surveys image (created using *F606W* and *F814W* filters) and (b) continuum-subtracted *HST* Hα image of DDO 68. Overlaid on both panels are the 2×10^{21} cm^{-2} column density contours derived from the 15″ resolution VLA H I images; the same contours are shown in Figure 2.
(A color version of this figure is available in the online journal.)

that the H I morphology of DDO 68 is significantly disturbed. Further, we have discovered a previously unknown, gas-bearing companion system that is connected to DDO 68 by a bridge of low surface brightness H I gas. Taken together, these lines of evidence suggest that DDO 68 is undergoing an interaction or accretion event; this may support the infall hypothesis.

2. OBSERVATIONS AND DATA REDUCTION

H I spectral-line observations of DDO 68 were acquired with the Karl G. Jansky Very Large Array (VLA)[14] in the *C* configuration in 2002 November for program AT 288. These data divide the 1.5 MHz total bandwidth into 256 channels, delivering a spectral resolution of 1.19 km s^{-1} ch^{-1}. The primary and phase calibrators were 3C286 and 0958+324, respectively. The total on-source integration time was approximately 8 hr. The VLA data were calibrated and imaged using standard prescriptions in the AIPS environment.[15] Residual flux rescaling was enforced during the image production process (Jorsater & van Moorsel 1995). The final beam size is 15″, and the rms noise in the final data cube is 0.5 mJy beam^{-1}. Moment maps were derived using the techniques described in Walter et al. (2008).

H I 21 cm spectral-line imaging of the DDO 68 system was obtained with the 100 m Robert C. Byrd Green Bank Telescope (GBT) in "on the fly mapping" (OTF) mode in 2014 January and February, for programs AGBT/13B-169 (PI: McQuinn) and AGBT/13B-459 (PI: Cannon). Briefly, the GBT spectrometer acquired data using in-band frequency switching with a bandwidth of 12.5 MHz, delivering a spectral resolution of 0.158 km s^{-1} ch^{-1}. The mapping region covered $\sim$1$^{\circ}_{.}$1 and was Nyquist sampled. Data calibration and baseline fitting was performed using standard GBTIDL[16] routines, with slight modifications compared to the previous data reduction methods in Johnson (2013). Specifically, after calibrating each row in the map, all baseline structures were removed by subtracting the average of the first and last four pixels in each row from the row itself. This improved fitting method delivers superior baseline fits compared to a more simplistic low-order polynomial fit to line-free spectral regions. Calibrated spectra were exported to AIPS for imaging. All spectra were combined into a single database and imaged using the SDGRD task with a spherical Bessel function (Mangum et al. 2007); the final, smoothed velocity resolution was 15.46 km s^{-1} ch^{-1}.

Optical images of DDO 68 and the companion system described below were acquired with the WIYN 0.9 m

14 The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

15 Developed and maintained by NRAO.

16 Developed by NRAO; documentation at http://gbtidl.sourceforge.net.

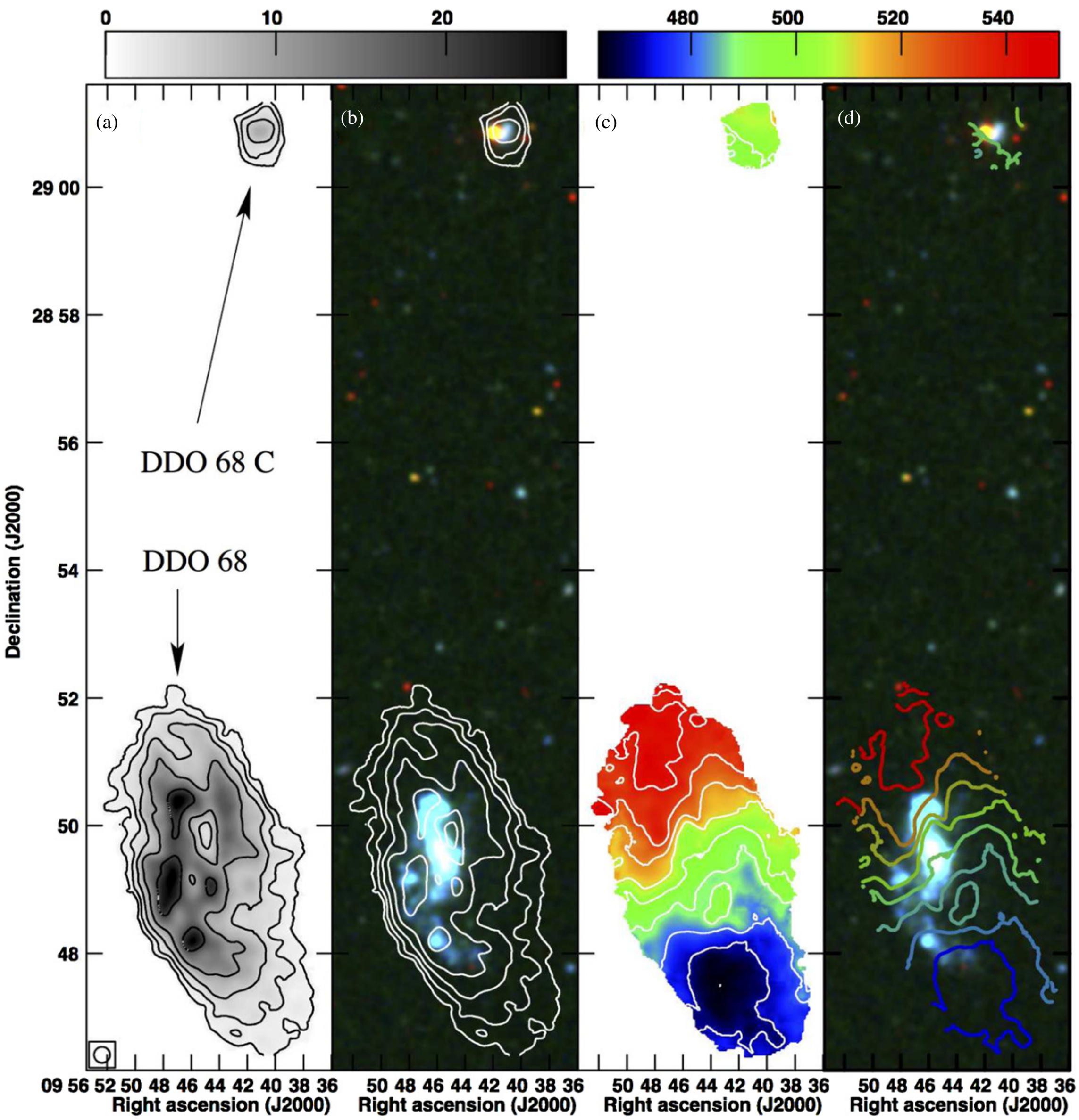

Figure 2. H I, optical, and near-UV images of DDO 68 and DDO 68 C. Panel (a) shows the VLA H I column density image (15″ beam shown at bottom left) overlaid with contours at the (1.25, 2.5, 5, 10, 20) × 10^{20} cm^{-2} levels; the same contours are overlaid on a spatially smoothed three-color image in panel (b) showing the DSS2-blue, *GALEX* near-UV, and *GALEX* far-UV images as red, green, and blue, respectively. Panel (c) shows the intensity weighted velocity field of the system, with contours spaced in 10 km s^{-1} intervals between 470 and 540 km s^{-1}; the same contours are overlaid on the three-color image in panel (d).

(A color version of this figure is available in the online journal.)

Telescope[17] on 2014 February 26. Two 20 minute exposures in a narrowband Hα filter, and one 4 minute exposure in a broadband *R* filter, were acquired. Continuum subtraction followed standard prescriptions.

Archival *HST*, *GALEX*, and Sloan Digital Sky Survey (SDSS) data were downloaded from the respective archives. The *HST* images of DDO 68 were acquired in program 11578 (PI: Aloisi). Standard photometric analysis of these data were performed using the DOLPHOT software package (Dolphin 2000). The resulting photometry yields a tip of the red giant branch distance of 12.74 ± 0.27 Mpc, which is used in this Letter. This value is significantly larger than previous (indirect method) distance estimates (e.g., Pustilnik et al. 2005 estimate $D \simeq 6.5$ Mpc). Accounting for the peculiar motions discussed in Tully et al. (2008), Pustilnik & Tepliakova (2011), and Karachentsev et al. (2013) estimated distances of ∼10 Mpc. Most recently, Tikhonov et al. (2014) use the same *HST* data as analyzed here to derive a distance of 12.3 ± 0.3 Mpc; they also interpret the color–magnitude diagram and stellar population distributions as evidence for an ongoing merger, and identify an interacting companion galaxy (“DDO 68 B”) that makes up the bulk of the stellar stream seen in the *HST* and *GALEX* images.

3. THE DDO 68–DDO 68 C SYSTEM

In Figure 2 we present the H I surface density image and the intensity weighted H I velocity field of the DDO 68 system. The H I morphology of DDO 68 is significantly disturbed: the H I surface density contours are compressed on the eastern side of

[17] The WIYN 0.9 m Telescope is operated by WIYN Inc. on behalf of a Consortium of nine partner Universities and Organizations (see http://www.noao.edu/0.9m). WIYN is a joint partnership of the University of Wisconsin at Madison, Indiana University, Yale University, and the National Optical Astronomical Observatory.

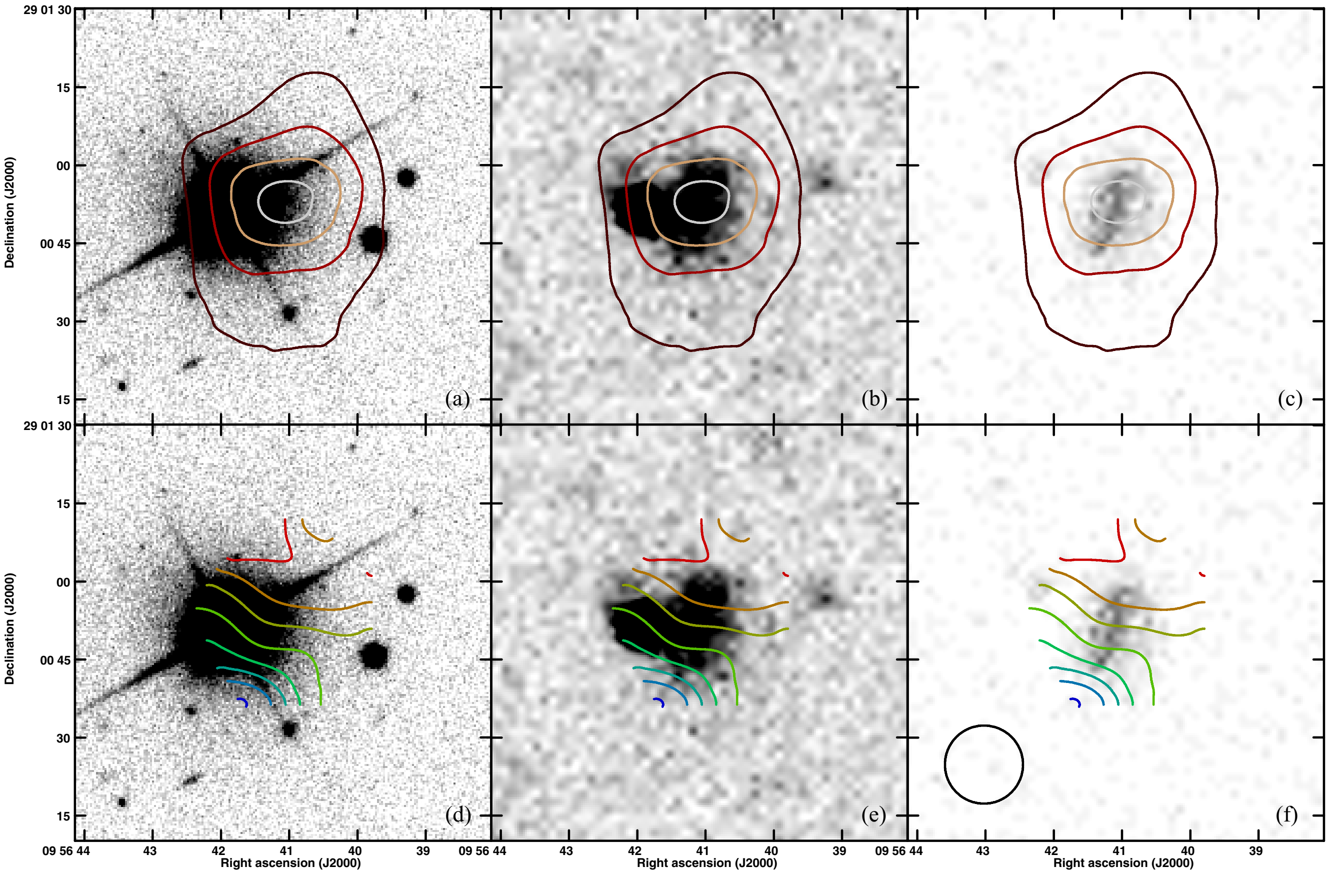

Figure 3. H I, optical, and UV images of the newly discovered galaxy DDO 68 C. Panels (a) and (d) show the SDSS r-band image; panels (b) and (e) show the *GALEX* near-UV image; panels (c) and (f) show the *GALEX* far-UV image. Overlaid on panels (a)–(c) are contours showing H I column densities at the (2, 4, 6, 8) × 10^{20} cm^{-2} levels. Overlaid on panels (d)–(f) are isovelocity contours between 494 and 508 km s^{-1}, in intervals of 2 km s^{-1}. The 15″ beam is shown in panel (f).

(A color version of this figure is available in the online journal.)

the galaxy, but are diffuse and filamentary to the south and west. The UV emission shows a similar morphology; the apparent stellar stream that extends to the south and west is co-spatial with the H I extending in the same sense.

The velocity field of DDO 68 shown in Figure 2 indicates coherent rotation. However, significant irregularities in the disk are apparent (note the kinks in the isovelocity contours in the velocity range 490–520 km s^{-1}). We thus only estimate the bulk kinematics via tilted ring analysis, and defer a full mass decomposition until a later work. Using the GIPSY task ROTCUR, we derived a representative rotation curve with the following dynamical parameters: $V_{\rm sys}$ = 505.5 km s^{-1}, major axis position angle (measured counterclockwise from north toward the receding side of the disk) = 19°.6, inclination i = 65°.2. A range of dynamical center positions yielded similar flat rotational velocities $v_c \simeq 45$ km s^{-1} at radii of 180″ (11.1 kpc). The challenges with fitting the rotation curve, and the estimates of the flat rotational velocity, are in agreement with the work of Ekta et al. (2008). A simple $(V_c^2 \cdot r/G)$ calculation gives a total dynamical mass estimate of $M_{\rm dyn} > 5.2 \times 10^9\ M_\odot$. This value is a lower limit because it only includes the mass within the H I radius, and because we have not applied a correction for possible non-circular motions. The derived H I flux integral ($S_{\rm H\,I}$ 26.0 ± 2.6 Jy km s^{-1}) implies $M_{\rm H\,I} = (1.0 \pm 0.15) \times 10^9\ M_\odot$. This can be compared with the stellar mass, derived using the total *Spitzer* 3.6 μm and 4.5 μm fluxes from Dale et al. (2009) and the formalism presented in Eskew et al. (2012): $M_\star \simeq 2 \times 10^8\ M_\odot$. Within the H I radius, DDO 68 is a dark-matter dominated galaxy.

In the VLA data cube we unexpectedly identified a nearby, gas-rich galaxy that has a systemic velocity identical to that of DDO 68. We hereafter refer to this companion as DDO 68 C. As Figure 2 shows, the angular separation of 11′.34 (measured from the UV centroid position of DDO 68 C at 09$^{\rm h}$56$^{\rm m}$41$^{\rm s}$.07, +29°00′50″.74 to the adopted dynamical center position of DDO 68 at 09$^{\rm h}$56$^{\rm m}$45$^{\rm s}$.79, +28°49′32″.9) implies a physical separation of ∼42 kpc. To our knowledge this source does not appear in the literature; it is not mentioned in the previous H I studies by Stil & Israel (2002) and Ekta et al. (2008).

DDO 68 C is detected at high significance in the H I data. As shown in the moment zero image presented in Figure 3, the H I column densities peak at 8.8 × 10^{20} cm^{-2} at 15″ (930 pc) resolution. Based on the derived flux integral ($S_{\rm H\,I}$ = 0.73 ± 0.11 Jy km s^{-1}), the total neutral hydrogen mass $M_{\rm H\,I}$ = (2.8 ± 0.5) × $10^7\ M_\odot$. The neutral hydrogen reservoir of DDO 68 is roughly 35 times more massive than that in DDO 68 C.

The lack of previous information about DDO 68 C may be due to the superposition of the Milky Way foreground star TYC 1967−1114−1 (m_V = 10.8; Høg et al. 2000). This star has unsaturated photometry in the *Tycho*, Two Micron All Sky Survey, and *WISE* catalogs; the solar-metallicity ATLAS9

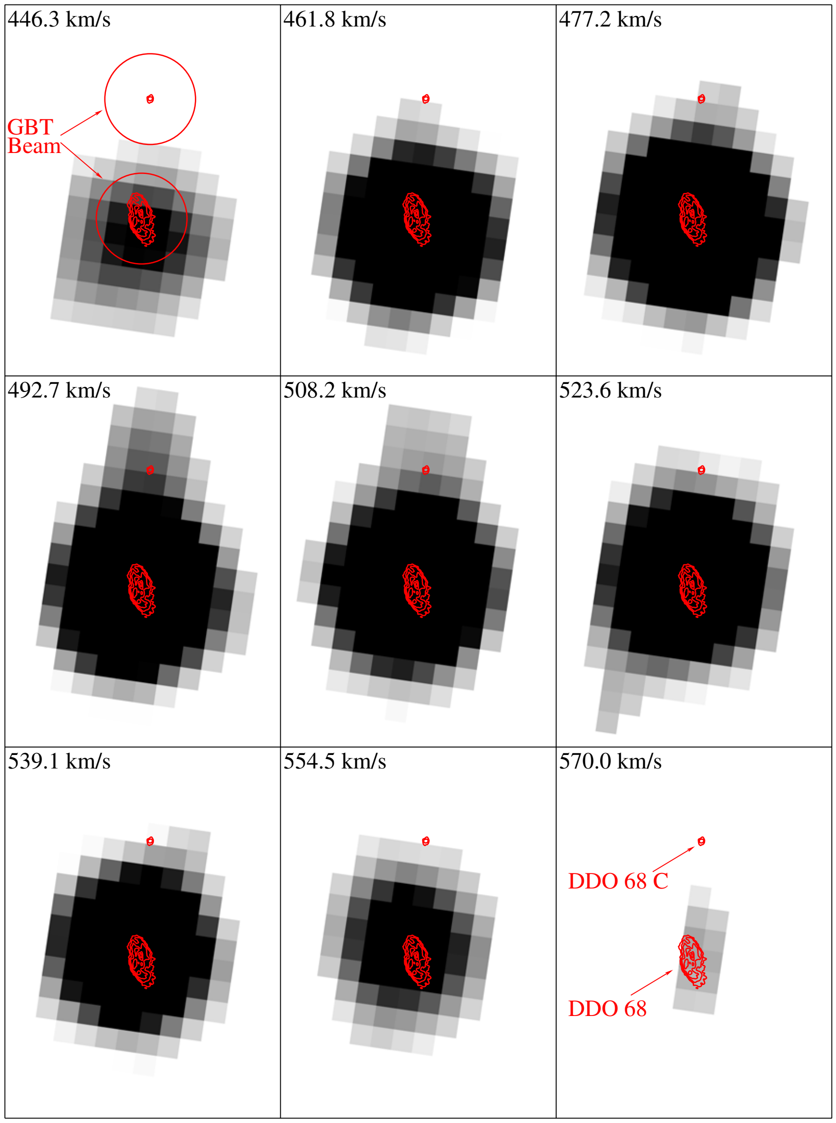

Figure 4. Channel maps of the spectrally smoothed GBT OTF mapping H I cube of the DDO 68 system; velocities are shown in the upper left of each panel. Pixel intensities range from 0.0 K (white) to 0.075 K (black); the field of view of each panel is ∼24′.9 × 33′.4. Red contours show the same VLA H I column density contours as in Figure 2. The GBT beam size (523″.3) is shown by the two red circles in the first panel; DDO 68 and DDO 68 C are each labeled in the last panel. The most extended northern and southern very low column density H I gas (V =493 and V =524 km s^{-1}) have velocities in the opposite directions as those visible in the adjacent parts of DDO 68; this could provide evidence for dynamically decoupled gas flows along a filament or remnant flows from the recent merger discussed in Ekta et al. (2008).

(A color version of this figure is available in the online journal.)

spectrum (Castelli & Kurucz 2003) that best-fits this photometry is a $T_{\rm eff}$ = 5000 K dwarf with spectral type between K0V and K2V in the Pickles (1998) library. As shown in Figure 3, this star is saturated in the SDSS r-band image. It is prominent in the *GALEX* near-UV, and is slightly above the noise level in the *GALEX* far-UV. The latter image clearly delineates the UV-bright stellar component of DDO 68 C, which is exactly co-spatial with the H I distribution.

The 15″ H I beam resolves the gas in DDO 68 C, and there is evidence for rotation in the images shown in Figure 3. The velocity field of DDO 68 C was derived using Gaussian fitting to emission above the 4σ level via the GIPSY task XGAUFIT. We do not have sufficient spatial resolution to attempt a formal dynamical analysis of DDO 68 C. However, a major-axis position–velocity (PV) slice through the 15″ data cube suggests a minimum (i.e., uncorrected for inclination, which is likely significant based on the far-UV morphology) rotation velocity of 7.5–10 km s^{-1}.

We estimate the SF rate (SFR) using the *GALEX* far-UV image shown in Figure 3. We derive an integrated far-UV magnitude $m_{\rm FUV}$ = 19.3 for DDO 68 C. Using the prescriptions in Salim et al. (2007), this corresponds to a far-UV SFR (SFR$_{\rm FUV}$) of (1.4 ± 0.4) ×10^{-3} $M_\odot$ yr^{-1}. This SFR$_{\rm FUV}$ is similar to those of the least massive dwarfs in Lee et al. (2009). For comparison, the SFR$_{\rm FUV}$ of DDO 68 is ∼20 times larger (SFR$_{\rm FUV}$ = 0.023 $M_\odot$ yr^{-1} and 0.029 $M_\odot$ yr^{-1} from Lee et al. 2009 and Hunter et al. 2010, respectively).

DDO 68 C is not detected in the WIYN 0.9 m continuum-subtracted Hα image. Assuming a point source, the upper limit of the integrated Hα luminosity is $L_{\rm H\alpha}$ < 8.5 × 10^{36} erg s^{-1}, corresponding to an Hα-based SFR upper limit SFR$_{\rm H\alpha}$ < 7 × 10^{-5} $M_\odot$ yr^{-1}. These lines of evidence suggest that despite

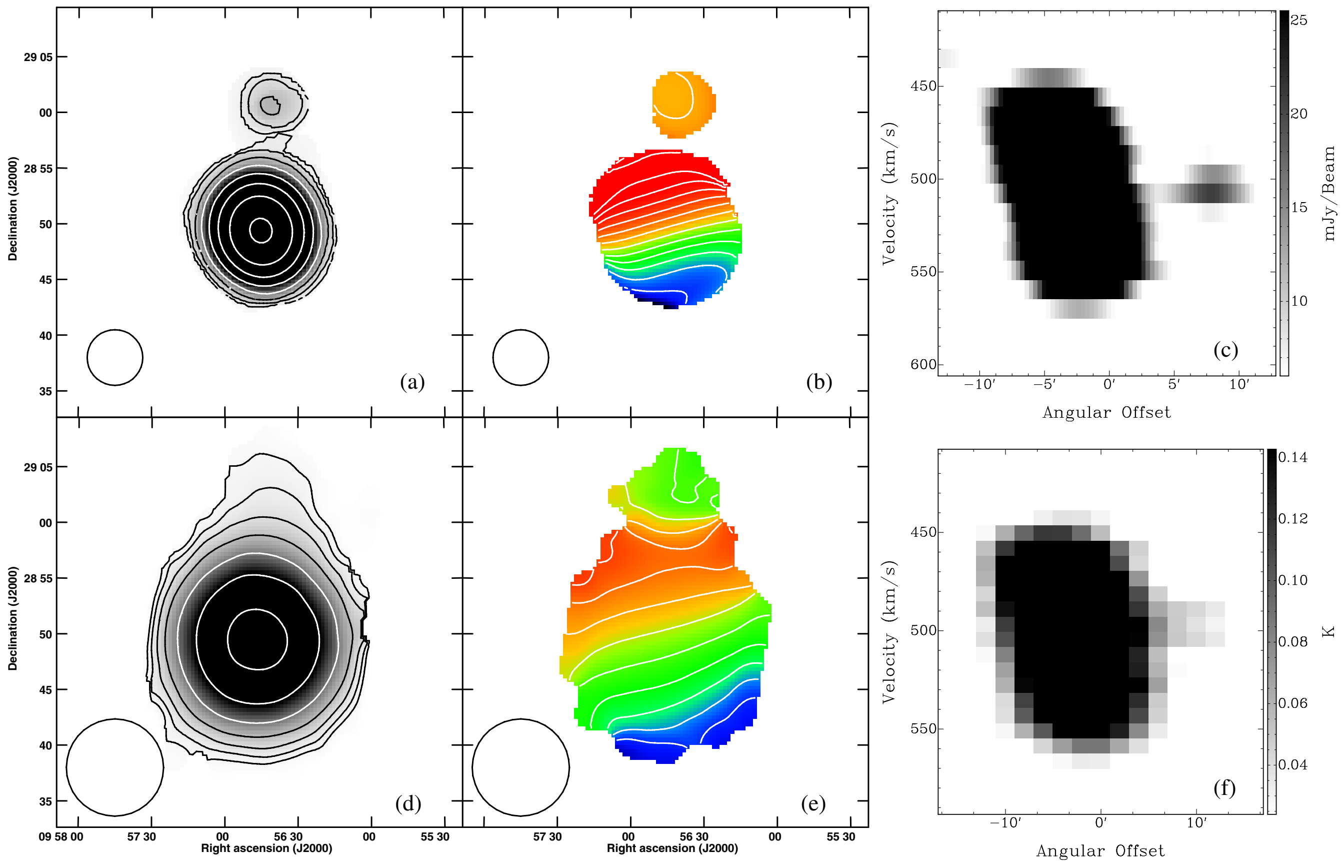

Figure 5. H I column density images, velocity fields, and PV slices of the DDO 68–DDO 68 C system. Panels (a)–(c) show the VLA data, tapered to an angular resolution of 300″, while panels (d)–(f) show the GBT data at an angular resolution of 523.″3; beam sizes are shown as circles in the bottom left of panels (a), (b), (d), and (e). The contours in panel (a) show H I column densities of (2, 4, 8, 16, 32, 128, 256) × 10^{18} cm^{-2}; the contours in panel (d) show H I column densities of (1, 2, 4, 8, 16, 32, 128, 256) × 10^{18} cm^{-2}. The contours in panels (b) and (e) show velocities between 475 and 530 km s^{-1}, in intervals of 5 km s^{-1}. The PV slices in panels (c) and (f) are taken at a position angle of 355° (measured counter-clockwise from north) and pass through the H I surface density maxima of both DDO 68 and DDO 68 C.

(A color version of this figure is available in the online journal.)

the higher SFR$_{\rm FUV}$ within the past few hundred Myr, the galaxy is now undergoing a period of relative quiescence or has a stochastically sampled upper initial mass function.

4. EVIDENCE FOR INTERACTION

In Figure 4 we show channel maps of the DDO 68–DDO 68 C system derived from our GBT OTF mapping observations. These images were created by blanking emission below the 3σ level in the smoothed 15.46 km s^{-1} ch^{-1} data cube (σ = 6 mK in line-free channels). Across multiple channels, emission extends from DDO 68 toward, and overlapping with, DDO 68 C. The two galaxies are connected by a bridge of low surface brightness gas with integrated H I column densities $\lesssim$5 × 10^{18} cm^{-2}.

The H I connecting DDO 68 and DDO 68 C is apparent in both the GBT and the VLA data. In Figure 5 we show H I column density images, Gaussian-fitted velocity fields, and PV slices from both data sets. Panels (a) and (b) show moment maps derived from the VLA data after applying spectral smoothing and Gaussian tapering in the *uv* plane; the resulting beam size and velocity resolution are 300″ and 10.3 km s^{-1} ch^{-1}, respectively. At this resolution and sensitivity, the low surface brightness H I gas appears between the two systems at a column density $N_{\rm H\,I} \simeq 2 \times 10^{18}$ cm^{-2}. In panels (d) and (e), the GBT data (beam size = 523.″3) clearly show the extension of the H I gas toward and enclosing DDO 68 C. This extended emission is apparent at integrated column densities of 1×10^{18} cm^{-2} $\lesssim N_{\rm H\,I} \lesssim 10^{19}$ cm^{-2} in the GBT data. Panels (c) and (f) show PV slices taken at a position angle of 355° (measured counter-clockwise from north) and passing through the H I surface density maxima of both DDO 68 and DDO 68 C. These panels clearly verify the presence of low surface brightness H I gas between DDO 68 and DDO 68 C.

It is important to note that the angular separation of the two galaxies (11.′34 using the coordinates discussed above) is slightly larger than the synthesized beam of the GBT OTF maps (8.′7). As Figure 4 shows, a GBT beam resolution element centered on each source does not overlap with the other; formally, the two sources are resolved. The presence of low surface brightness H I gas in the VLA data assures that this bridge is not entirely a resolution or smoothing effect. Very deep, low-resolution interferometric images of this system would be valuable in further studying the nature of the gas between DDO 68 and its companion.

We interpret the low surface brightness H I gas connecting DDO 68 and its companion as direct evidence for an ongoing interaction. This interpretation is strengthened by the various lines of discussion in Section 1. Specifically, the optical and H I morphologies of DDO 68 are both severely disturbed. Further, the ongoing massive SF is concentrated in regions of the outer disk and in the stellar stream extending to the south.

5. DISCUSSION

The ongoing interaction of DDO 68 and DDO 68 C provides a possible explanation for the deviation of DDO 68 from the *M–Z* relationship. The present-day metallicity of the H II regions may be a result of the complex mixing of infalling neutral material. As discussed in detail in Sancisi et al. (2008), the close proximity of gas-rich companions and the presence of H I and stellar tails (all of which are seen in the DDO 68–DDO 68 C system) provide compelling support for ongoing cold gas accretion.

With the present data we cannot conclude that the interaction is responsible for the infall of pristine gas into the DDO 68 disk. While it is possible that deep, interferometric low-resolution H I imaging could separate infalling gas from material associated with an interaction, it is likely that an alternative method will be needed to identify an infall episode. UV absorption line spectroscopy offers one avenue for such investigation (see, e.g., Lebouteiller et al. 2013). An alternative method would be to examine elemental abundances in all available H II regions in the disk; to date only abundances for the northern H II regions have been derived (Pustilnik et al. 2005; Berg et al. 2012). A measurement of the abundances in the H II region in the stellar stream to the south (see Hα image in Figure 1) would reveal if the entire disk of DDO 68 has experienced a uniform level of chemical enrichment. Unfortunately, the Hα non-detection of DDO 68 C precludes a spectroscopic measurement of its chemical abundance.

As DDO 68 and its companion appear to be interacting, it would be especially interesting to compare the recent SF histories (SFHs) of these systems. As discussed in McQuinn et al. (2010a, 2010b, 2012), spatially resolved SFHs offer unique insights into the locations and intensities of SF as functions of time. New *HST* observations of DDO 68 C that are similar to the archival observations of DDO 68 shown in Figure 1 would allow a comparative SFH analysis between these two galaxies. The Hα non-detection but significant far-UV luminosity of DDO 68 C enforces the importance of probing the evolution of these systems over the past few hundred Myr. Correlated features in these SFHs would provide an empirical timescale on the interaction event.

J.M.C. is supported by NSF grant 1211683. The authors thank D. J. Pisano, Spencer Wolfe, and Dominic Ludovici for sharing their software, and Glen Langston for help with imaging the GBT data. Some of the results in this Letter are based on observations made with the NASA/ESA *Hubble Space Telescope*, obtained from the Data Archive at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. The *HST* observations presented in this work are associated with program No. 11578.

REFERENCES

Berg, D. A., Skillman, E. D., Marble, A. R., et al. 2012, ApJ, 754, 98
Bernstein-Cooper, E. Z., Cannon, J. M., Elson, E. C., et al. 2014, AJ, in press (arXiv:1404.5298)
Castelli, F., & Kurucz, R. L. 2003, in IAU Symp. 210, Modelling of Stellar Atmospheres, ed. N. Piskunov, W. W. Weiss, & D. F. Gray (San Francisco, CA: ASP), 20
Dale, D. A., Cohen, S. A., Johnson, L. C., et al. 2009, ApJ, 703, 517
Dolphin, A. E. 2000, PASP, 112, 1383
Ekta, B., & Chengalur, J. N. 2010, MNRAS, 406, 1238
Ekta, B., Chengalur, J. N., & Pustilnik, S. A. 2008, MNRAS, 391, 881
Eskew, M., Zaritsky, D., & Meidt, S. 2012, AJ, 143, 139
Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, A&A, 355, L27
Hunter, D. A., Elmegreen, B. G., & Ludka, B. C. 2010, AJ, 139, 447
Izotov, Y. I., Thuan, T. X., & Guseva, N. G. 2005, ApJ, 632, 210
Johnson, M. 2013, AJ, 145, 146
Jorsater, S., & van Moorsel, G. A. 1995, AJ, 110, 2037
Karachentsev, I. D., Makarov, D. I., & Kaisina, E. I. 2013, AJ, 145, 101
Lebouteiller, V., Heap, S., Hubeny, I., & Kunth, D. 2013, A&A, 553, A16
Lee, J. C., Gil de Paz, A., Tremonti, C., et al. 2009, ApJ, 706, 599
Mangum, J. G., Emerson, D. T., & Greisen, E. W. 2007, A&A, 474, 679
McQuinn, K. B. W., Skillman, E. D., Cannon, J. M., et al. 2010a, ApJ, 721, 297
McQuinn, K. B. W., Skillman, E. D., Cannon, J. M., et al. 2010b, ApJ, 724, 49
McQuinn, K. B. W., Skillman, E. D., Dalcanton, J. J., et al. 2012, ApJ, 759, 77
Pickles, A. J. 1998, PASP, 110, 863
Pustilnik, S. A., Kniazev, A. Y., & Pramskij, A. G. 2005, A&A, 443, 91
Pustilnik, S. A., & Tepliakova, A. L. 2011, MNRAS, 415, 1188
Salim, S., Rich, R. M., Charlot, S., et al. 2007, ApJS, 173, 267
Sancisi, R., Fraternali, F., Oosterloo, T., & van der Hulst, T. 2008, A&ARv, 15, 189
Skillman, E. D., & Kennicutt, R. C., Jr. 1993, ApJ, 411, 655
Skillman, E. D., Salzer, J. J., Berg, D. A., et al. 2013, AJ, 146, 3
Stil, J. M., & Israel, F. P. 2002, A&A, 389, 29
Tikhonov, N. A., Galazutdinova, O. A., & Lebedev, V. S. 2014, AstL, 40, 1
Tully, R. B., Shaya, E. J., Karachentsev, I. D., et al. 2008, ApJ, 676, 184
Walter, F., Brinks, E., de Blok, W. J. G., et al. 2008, AJ, 136, 2563
van Zee, L., Westpfahl, D., Haynes, M. P., & Salzer, J. J. 1998, AJ, 115, 1000