

Observing Application

Date: Aug 02, 2021
Proposal ID: GBT/22A-430
Legacy ID: QR301
PI: Joseph Ribaldo
Type: Regular
Category: Extragalactic Structure
Total time: 133.0

The Baryonic Tully-Fisher Relation for Galaxies with Supernova Distances

Abstract:

The Baryonic Tully-Fisher Relation (BTFR), an empirical scaling relation that appears to link the baryonic mass of a disk galaxy to its rotational velocity, is used both to constrain models of how baryons inhabit their host halos and, of particular relevance to this proposal, to estimate galaxy distances. The comparison of redshifts expected for those estimated distances in pure Hubble flow with observed redshifts yields peculiar velocities which in turn can be used to probe the large-scale gravitational field. Using the BTFR to trace mass distributions requires a robustly determined template BTFR whose scatter is minimized, and well understood. Yet current templates are limited in their understanding of their uncertainties either due to small sample sizes or large distance uncertainties. Thus, we propose HI 21 cm line observations of 220 galaxies which have accurate distance measurements derived from the supernovae they host. These observations will allow for the construction of a well understood, minimal scatter template BTFR.

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Related Proposals:

Joint:

Not a Joint Proposal.

Observing type(s):

Spectroscopy

GBT Resources

Name	Group	Frontend & Backend	Setup
Redshifted HI	Observation Mode	L-Band (1.15-1.73 GHz) VEGAS	Observing type: Spectral Line Number of beams: 1 Number of spectrometers: 1

Spectrometer #	1
Mode	10
Bandwidth (MHz)	23.44
Rest frequencies (GHz)	1.421
Spectral resolution (KHz)	0.7
Integration time (s)	5.0
Data rate (MB/s)	0.1

Sources

Name	Position		Velocity		Group
646	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:03:26.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+32:14:13.0	Velocity	5298	
		00:00:00			
Calibrator	No				
1324	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:51:36.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+19:06:12.0	Velocity	10088	
		00:00:00			
Calibrator	No				
1993	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:31:39.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+39:22:41.0	Velocity	8019	
		00:00:00			
Calibrator	No				
2164	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:41:09.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+43:40:56.0	Velocity	6854	
		00:00:00			
Calibrator	No				
2353	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:52:51.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+42:12:18.0	Velocity	3588	
		00:00:00			
Calibrator	No				
2384	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:55:00.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+16:00:44.0	Velocity	9836	
		00:00:00			
Calibrator	No				

Name	Position		Velocity		Group
2561	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:09:42.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:58:27.0	Velocity	6025	
00:00:00					
Calibrator	No				
3151	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:45:19.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+11:04:04.0	Velocity	4622	
00:00:00					
Calibrator	No				
3232	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:03:18.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+18:27:09.0	Velocity	5009	
00:00:00					
Calibrator	No				
3329	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:36:32.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+16:38:27.0	Velocity	5266	
00:00:00					
Calibrator	No				
3376	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:54:40.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+15:10:16.0	Velocity	3952	
00:00:00					
Calibrator	No				
3611	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:57:11.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+20:26:14.0	Velocity	4983	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
3634	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	07:01:36.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+14:08:05.0	Velocity	7891	
00:00:00					
Calibrator	No				
3738	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	07:12:15.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+07:14:24.0	Velocity	8496	
00:00:00					
Calibrator	No				
3770	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	07:15:29.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+23:25:41.0	Velocity	6378	
00:00:00					
Calibrator	No				
3845	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	07:26:42.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+47:05:39.0	Velocity	3034	
00:00:00					
Calibrator	No				
4133	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:00:08.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+56:21:55.0	Velocity	8905	
00:00:00					
Calibrator	No				
4455	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:31:32.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-1:11:53.0	Velocity	9299	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
4481	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:34:33.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-2:32:48.0	Velocity	4222	
00:00:00					
Calibrator	No				
4510	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:40:50.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+73:29:11.0	Velocity	3623	
00:00:00					
Calibrator	No				
4614	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:49:16.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+36:07:10.0	Velocity	7556	
00:00:00					
Calibrator	No				
4664	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:54:46.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+39:32:18.0	Velocity	3991	
00:00:00					
Calibrator	No				
5066	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:31:07.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+46:23:03.0	Velocity	5063	
00:00:00					
Calibrator	No				
5322	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:55:52.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+69:40:49.0	Velocity	267	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
5609	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:24:22.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+78:36:31.0	Velocity	2775	
00:00:00					
Calibrator	No				
5645	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:27:11.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+71:25:03.0	Velocity	10493	
00:00:00					
Calibrator	No				
5814	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:42:38.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+77:29:40.0	Velocity	1881	
00:00:00					
Calibrator	No				
6015	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:54:02.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+46:01:39.0	Velocity	12468	
00:00:00					
Calibrator	No				
6363	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:21:00.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+21:20:13.0	Velocity	6306	
00:00:00					
Calibrator	No				
6904	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:55:45.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+55:19:14.0	Velocity	1128	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
7847	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:41:05.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+50:23:37.0	Velocity	4650	
00:00:00					
Calibrator	No				
7879	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:42:49.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+10:21:25.0	Velocity	7603	
00:00:00					
Calibrator	No				
7935	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:45:31.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+54:44:14.0	Velocity	4798	
00:00:00					
Calibrator	No				
8399	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:21:45.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+31:14:11.0	Velocity	7270	
00:00:00					
Calibrator	No				
8455	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:27:16.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+32:01:48.0	Velocity	7294	
00:00:00					
Calibrator	No				
8503	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:30:44.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+32:45:37.0	Velocity	4674	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
9391	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:34:36.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+59:20:15.0	Velocity	1921	
00:00:00					
Calibrator	No				
9419	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:37:14.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+38:27:14.0	Velocity	3679	
00:00:00					
Calibrator	No				
10030	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:47:00.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-00:59:08.0	Velocity	8960	
00:00:00					
Calibrator	No				
10156	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:02:49.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+47:13:25.0	Velocity	6080	
00:00:00					
Calibrator	No				
10244	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:09:55.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+43:07:44.0	Velocity	9777	
00:00:00					
Calibrator	No				
10483	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:34:28.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+76:01:45.0	Velocity	12202	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
10592	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:52:58.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+02:24:01.0	Velocity	7287	
00:00:00					
Calibrator	No				
11097	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	18:02:24.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+26:02:39.0	Velocity	4598	
00:00:00					
Calibrator	No				
11128	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	18:09:20.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+18:17:51.0	Velocity	5331	
00:00:00					
Calibrator	No				
11198	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	18:18:59.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+16:14:57.0	Velocity	4529	
00:00:00					
Calibrator	No				
11260	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	18:30:25.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+34:06:10.0	Velocity	6266	
00:00:00					
Calibrator	No				
11409	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	19:10:37.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+37:39:19.0	Velocity	8347	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
11470	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	19:43:40.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+56:06:32.0	Velocity	3551	
00:00:00					
Calibrator	No				
11478	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	19:47:07.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+59:54:24.0	Velocity	3291	
00:00:00					
Calibrator	No				
11554	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	20:23:33.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+58:20:38.0	Velocity	3099	
00:00:00					
Calibrator	No				
11560	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	20:26:25.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+02:54:34.0	Velocity	4961	
00:00:00					
Calibrator	No				
11628	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	20:47:19.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+00:19:15.0	Velocity	4218	
00:00:00					
Calibrator	No				
11758	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:30:57.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+13:59:09.0	Velocity	8614	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
11980	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:18:17.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:33:44.0	Velocity	1170	
00:00:00					
Calibrator	No				
12071	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:32:24.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+30:50:07.0	Velocity	10396	
00:00:00					
Calibrator	No				
12833	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:53:32.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+08:07:04.0	Velocity	5210	
00:00:00					
Calibrator	No				
20503	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:45:32.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-26:33:53.0	Velocity	6831	
00:00:00					
Calibrator	No				
21306	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:40:21.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-28:54:50.0	Velocity	5462	
00:00:00					
Calibrator	No				
22318	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:05:15.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-39:33:41.0	Velocity	6045	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
22699	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:33:36.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-36:08:25.0	Velocity	1639	
00:00:00					
Calibrator	No				
23036	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:54:24.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-19:11:25.0	Velocity	6497	
00:00:00					
Calibrator	No				
23161	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:04:28.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-17:54:21.0	Velocity	8115	
00:00:00					
Calibrator	No				
24007	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:05:08.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-18:59:14.0	Velocity	7801	
00:00:00					
Calibrator	No				
24223	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:22:17.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-25:36:11.0	Velocity	9407	
00:00:00					
Calibrator	No				
25281	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:41:03.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-38:02:08.0	Velocity	10195	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
26163	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:47:16.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-20:02:09.0	Velocity	4581	
00:00:00					
Calibrator	No				
26706	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:55:09.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-33:08:14.0	Velocity	3018	
00:00:00					
Calibrator	No				
26744	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:58:56.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-18:49:06.0	Velocity	12224	
00:00:00					
Calibrator	No				
27869	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:23:41.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-22:16:15.0	Velocity	8314	
00:00:00					
Calibrator	No				
27994	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:37:59.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-32:19:30.0	Velocity	8819	
00:00:00					
Calibrator	No				
28275	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:01:52.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-18:51:47.0	Velocity	1624	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
28479	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:21:16.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-21:59:43.0	Velocity	6854	
00:00:00					
Calibrator	No				
28561	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:28:27.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-24:38:11.0	Velocity	3302	
00:00:00					
Calibrator	No				
28810	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:47:30.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-39:34:15.0	Velocity	4649	
00:00:00					
Calibrator	No				
29563	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:23:22.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-26:06:34.0	Velocity	9484	
00:00:00					
Calibrator	No				
29581	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:24:10.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-23:52:38.0	Velocity	7556	
00:00:00					
Calibrator	No				
29613	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:25:32.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-24:39:11.0	Velocity	9952	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
29960	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:39:55.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-31:38:31.0	Velocity	417	
00:00:00					
Calibrator	No				
30270	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:58:17.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-23:22:18.0	Velocity	10970	
00:00:00					
Calibrator	No				
32512	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	19:24:20.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-25:59:06.0	Velocity	6093	
00:00:00					
Calibrator	No				
34954	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:01:37.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-21:30:43.0	Velocity	5189	
00:00:00					
Calibrator	No				
35788	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:56:41.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-36:46:22.0	Velocity	2102	
00:00:00					
Calibrator	No				
35810	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:57:54.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-35:51:29.0	Velocity	1926	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
36444	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:54:45.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-25:40:23.0	Velocity	9091	
00:00:00					
Calibrator	No				
36498	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:57:49.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-32:35:30.0	Velocity	231	
00:00:00					
Calibrator	No				
36511	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:58:31.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-18:42:50.0	Velocity	10206	
00:00:00					
Calibrator	No				
100038	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:06:14.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+08:53:16.0	Velocity	11539	
00:00:00					
Calibrator	No				
100539	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:46:38.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+36:19:52.0	Velocity	11229	
00:00:00					
Calibrator	No				
103059	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:35:10.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+23:15:18.0	Velocity	11032	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
105046	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:15:00.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+16:20:00.0	Velocity	8334	
00:00:00					
Calibrator	No				
111609	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:27:06.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+19:06:59.0	Velocity	12924	
00:00:00					
Calibrator	No				
111724	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:49:42.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+32:37:31.0	Velocity	11281	
00:00:00					
Calibrator	No				
114578	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:24:22.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+03:35:17.0	Velocity	7381	
00:00:00					
Calibrator	No				
116545	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:11:49.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+14:38:27.0	Velocity	11692	
00:00:00					
Calibrator	No				
116546	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:01:35.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+17:06:04.0	Velocity	9275	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
120493	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:45:49.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+03:13:51.0	Velocity	6805	
00:00:00					
Calibrator	No				
120570	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:54:16.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+42:43:32.0	Velocity	6331	
00:00:00					
Calibrator	No				
121124	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:49:10.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+14:36:03.0	Velocity	8727	
00:00:00					
Calibrator	No				
125371	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:29:17.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+18:05:17.0	Velocity	4540	
00:00:00					
Calibrator	No				
125814	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:18:18.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+37:27:52.0	Velocity	8994	
00:00:00					
Calibrator	No				
125815	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:52:57.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+01:36:23.0	Velocity	10794	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
125817	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:15:58.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+12:14:14.0	Velocity	5773	
00:00:00					
Calibrator	No				
130214	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:23:00.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+01:21:54.0	Velocity	9901	
00:00:00					
Calibrator	No				
131345	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:26:01.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:41:41.0	Velocity	4195	
00:00:00					
Calibrator	No				
140442	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:45:25.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+18:25:05.0	Velocity	4639	
00:00:00					
Calibrator	No				
151168	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:47:44.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+53:36:24.0	Velocity	7920	
00:00:00					
Calibrator	No				
160387	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:50:37.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+31:07:23.0	Velocity	5462	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
160904	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:37:16.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+49:51:00.0	Velocity	5786	
00:00:00					
Calibrator	No				
175126	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	07:30:17.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+25:01:54.0	Velocity	12799	
00:00:00					
Calibrator	No				
180952	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:11:43.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+41:33:18.0	Velocity	9458	
00:00:00					
Calibrator	No				
184750	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:05:19.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+22:57:51.0	Velocity	13414	
00:00:00					
Calibrator	No				
190579	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:53:49.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+09:11:37.0	Velocity	8991	
00:00:00					
Calibrator	No				
191474	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:09:33.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+50:16:58.0	Velocity	4888	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
194224	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:03:47.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+29:09:36.0	Velocity	6790	
00:00:00					
Calibrator	No				
198643	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:45:03.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+64:15:27.0	Velocity	5298	
00:00:00					
Calibrator	No				
200048	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:05:44.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+10:16:30.0	Velocity	7160	
00:00:00					
Calibrator	No				
200208	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:15:42.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+55:40:02.0	Velocity	7254	
00:00:00					
Calibrator	No				
201353	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:19:17.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+04:45:47.0	Velocity	13758	
00:00:00					
Calibrator	No				
204628	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:03:13.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+01:53:43.0	Velocity	13657	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
204982	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:48:07.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+00:10:02.0	Velocity	11758	
00:00:00					
Calibrator	No				
206431	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:26:42.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+36:40:53.0	Velocity	7387	
00:00:00					
Calibrator	No				
207676	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:37:32.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+65:01:06.0	Velocity	6757	
00:00:00					
Calibrator	No				
215538	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:17:48.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+13:43:40.0	Velocity	7462	
00:00:00					
Calibrator	No				
219861	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:01:19.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+70:39:55.0	Velocity	9245	
00:00:00					
Calibrator	No				
221146	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:56:53.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+22:22:25.0	Velocity	6663	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
222248	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:54:49.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+58:52:56.0	Velocity	2580	
00:00:00					
Calibrator	No				
226495	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:46:24.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+11:56:58.0	Velocity	13748	
00:00:00					
Calibrator	No				
229559	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:05:20.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:56:44.0	Velocity	13791	
00:00:00					
Calibrator	No				
229560	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:11:33.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+47:16:29.0	Velocity	9449	
00:00:00					
Calibrator	No				
231074	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:23:16.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+52:39:13.0	Velocity	9037	
00:00:00					
Calibrator	No				
239288	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:32:13.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+84:40:43.0	Velocity	7176	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
239289	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:36:47.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+05:08:33.0	Velocity	13569	
00:00:00					
Calibrator	No				
240937	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:54:39.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+42:01:26.0	Velocity	2510	
00:00:00					
Calibrator	No				
256294	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:22:41.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+50:58:36.0	Velocity	10417	
00:00:00					
Calibrator	No				
257439	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:52:55.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+65:56:08.0	Velocity	10920	
00:00:00					
Calibrator	No				
260804	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:49:51.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:26:00.0	Velocity	8863	
00:00:00					
Calibrator	No				
261094	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:37:29.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:52:48.0	Velocity	7838	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
270260	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:44:08.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:52:02.0	Velocity	12108	
00:00:00					
Calibrator	No				
270462	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:11:59.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+46:33:24.0	Velocity	6892	
00:00:00					
Calibrator	No				
272733	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:59:29.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+43:23:31.0	Velocity	7656	
00:00:00					
Calibrator	No				
272734	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:35:37.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+08:48:39.0	Velocity	10663	
00:00:00					
Calibrator	No				
272735	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:17:18.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+33:27:47.0	Velocity	9102	
00:00:00					
Calibrator	No				
272736	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:04:16.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+41:30:37.0	Velocity	9893	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
272737	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:17:50.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+40:52:52.0	Velocity	9401	
00:00:00					
Calibrator	No				
272738	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:23:41.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+30:29:51.0	Velocity	7009	
00:00:00					
Calibrator	No				
272739	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	17:34:40.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+26:18:18.0	Velocity	8600	
00:00:00					
Calibrator	No				
290421	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	19:19:27.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+44:14:49.0	Velocity	12600	
00:00:00					
Calibrator	No				
300486	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	20:54:35.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+56:29:53.0	Velocity	4446	
00:00:00					
Calibrator	No				
310069	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:20:42.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+44:23:59.0	Velocity	3988	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
310983	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:23:41.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+33:07:08.0	Velocity	14821	
00:00:00					
Calibrator	No				
311262	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:39:41.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+24:24:18.0	Velocity	11092	
00:00:00					
Calibrator	No				
311400	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:12:23.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+14:46:45.0	Velocity	9068	
00:00:00					
Calibrator	No				
320249	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:33:50.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+20:48:19.0	Velocity	10308	
00:00:00					
Calibrator	No				
321738	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:16:11.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+37:28:28.0	Velocity	5402	
00:00:00					
Calibrator	No				
323628	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:14:40.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+05:04:43.0	Velocity	7791	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
323629	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:53:24.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+04:47:58.0	Velocity	7256	
00:00:00					
Calibrator	No				
323630	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:25:31.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+38:59:02.0	Velocity	9543	
00:00:00					
Calibrator	No				
323632	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:01:49.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+13:03:20.0	Velocity	9346	
00:00:00					
Calibrator	No				
331536	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:37:56.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+27:16:36.0	Velocity	8394	
00:00:00					
Calibrator	No				
337143	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:19:02.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+13:47:26.0	Velocity	14690	
00:00:00					
Calibrator	No				
337144	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:40:14.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+26:12:10.0	Velocity	9593	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
400635	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	00:56:18.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-1:37:33.0	Velocity	13422	
00:00:00					
Calibrator	No				
411448	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:38:36.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-4:40:58.0	Velocity	14625	
00:00:00					
Calibrator	No				
411450	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	01:34:14.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-17:48:37.0	Velocity	13291	
00:00:00					
Calibrator	No				
421112	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:23:13.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-4:31:02.0	Velocity	5393	
00:00:00					
Calibrator	No				
421115	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	02:31:04.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-20:08:46.0	Velocity	9903	
00:00:00					
Calibrator	No				
430063	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:08:48.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-7:02:26.0	Velocity	9014	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
430359	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:35:01.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-24:56:00.0	Velocity	1472	
00:00:00					
Calibrator	No				
430428	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:42:16.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-4:43:51.0	Velocity	4218	
00:00:00					
Calibrator	No				
430559	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:49:05.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:03:38.0	Velocity	4057	
00:00:00					
Calibrator	No				
431482	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:49:43.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:15:35.0	Velocity	3855	
00:00:00					
Calibrator	No				
431483	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	03:01:32.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-15:01:03.0	Velocity	9225	
00:00:00					
Calibrator	No				
440420	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:56:59.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-4:45:25.0	Velocity	3936	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
440970	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:06:14.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-8:53:11.0	Velocity	11006	
00:00:00					
Calibrator	No				
441221	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	04:03:26.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-5:29:31.0	Velocity	11510	
00:00:00					
Calibrator	No				
450525	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	05:17:34.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-23:47:01.0	Velocity	9393	
00:00:00					
Calibrator	No				
460003	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:04:33.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-12:37:14.0	Velocity	2215	
00:00:00					
Calibrator	No				
460362	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:03:16.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-26:53:55.0	Velocity	9638	
00:00:00					
Calibrator	No				
460363	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	06:11:30.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-16:29:09.0	Velocity	5673	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
480379	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:32:57.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:51:30.0	Velocity	9169	
00:00:00					
Calibrator	No				
480381	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	08:35:02.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-8:20:13.0	Velocity	12902	
00:00:00					
Calibrator	No				
490057	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:16:10.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-16:18:47.0	Velocity	2368	
00:00:00					
Calibrator	No				
490064	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:20:22.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-7:52:53.0	Velocity	3440	
00:00:00					
Calibrator	No				
490778	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:44:32.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-12:18:24.0	Velocity	13922	
00:00:00					
Calibrator	No				
490781	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:59:18.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-19:28:23.0	Velocity	3650	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
500202	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:50:17.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-12:06:33.0	Velocity	4606	
00:00:00					
Calibrator	No				
501715	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:36:35.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-7:06:46.0	Velocity	8214	
00:00:00					
Calibrator	No				
501818	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:03:35.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-35:27:41.0	Velocity	14718	
00:00:00					
Calibrator	No				
501819	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	10:48:48.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-20:15:44.0	Velocity	3904	
00:00:00					
Calibrator	No				
510055	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:23:59.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-12:17:47.0	Velocity	5014	
00:00:00					
Calibrator	No				
510089	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:33:11.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-10:13:47.0	Velocity	6413	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
520068	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:31:04.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-8:03:14.0	Velocity	1037	
00:00:00					
Calibrator	No				
520167	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:49:41.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-11:05:34.0	Velocity	4103	
00:00:00					
Calibrator	No				
520432	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:14:11.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-00:49:53.0	Velocity	7417	
00:00:00					
Calibrator	No				
521469	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	12:05:24.9	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-21:23:57.0	Velocity	9575	
00:00:00					
Calibrator	No				
530083	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:16:58.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-16:38:04.0	Velocity	1749	
00:00:00					
Calibrator	No				
530277	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:31:04.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-15:06:03.0	Velocity	4233	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
531590	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:32:42.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-21:48:04.0	Velocity	8835	
00:00:00					
Calibrator	No				
531591	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:49:49.1	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:04:48.0	Velocity	14033	
00:00:00					
Calibrator	No				
531592	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	09:00:13.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-13:38:04.0	Velocity	9228	
00:00:00					
Calibrator	No				
531593	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	13:43:23.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-19:56:38.0	Velocity	9142	
00:00:00					
Calibrator	No				
540121	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:42:23.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-17:15:06.0	Velocity	2793	
00:00:00					
Calibrator	No				
540155	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:56:33.0	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-2:06:23.0	Velocity	6876	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
540314	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:20:58.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-22:45:24.0	Velocity	7795	
00:00:00					
Calibrator	No				
540932	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	14:07:32.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-26:33:06.0	Velocity	13799	
00:00:00					
Calibrator	No				
550003	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:03:45.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:18:09.0	Velocity	6366	
00:00:00					
Calibrator	No				
550056	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:21:32.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-7:22:38.0	Velocity	1928	
00:00:00					
Calibrator	No				
550256	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:45:30.5	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-13:09:06.0	Velocity	8550	
00:00:00					
Calibrator	No				
560035	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	16:16:33.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-00:35:20.0	Velocity	4936	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
610146	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	22:00:02.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-30:11:05.0	Velocity	5187	
00:00:00					
Calibrator	No				
610773	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:09:07.4	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-18:06:08.0	Velocity	6367	
00:00:00					
Calibrator	No				
610776	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	21:28:41.8	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-00:04:02.0	Velocity	11992	
00:00:00					
Calibrator	No				
630248	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:41:47.3	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-3:40:08.0	Velocity	6601	
00:00:00					
Calibrator	No				
630249	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:41:52.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-8:38:53.0	Velocity	10282	
00:00:00					
Calibrator	No				
630346	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:58:57.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-2:14:58.0	Velocity	7646	
00:00:00					
Calibrator	No				

Name	Position		Velocity		Group
630902	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:06:39.6	Ref. frame	Heliocentric	
		00:00:00			
	Declination	-12:34:24.0	Velocity	9921	
00:00:00					
Calibrator	No				
716159	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	15:06:02.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+07:33:41.0	Velocity	11297	
00:00:00					
Calibrator	No				
723820	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	11:38:33.7	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+25:23:53.0	Velocity	7583	
00:00:00					
Calibrator	No				
729972	Coordinate system	Equatorial	Convention	Optical	SNe Host
	Equinox	J2000			
	Right Ascension	23:21:19.2	Ref. frame	Heliocentric	
		00:00:00			
	Declination	+00:15:32.0	Velocity	9212	
00:00:00					
Calibrator	No				

Sessions:

Name	Session time (hours)	Repeat	Separation	LST minimum	LST maximum	Elevation minimum
HI Observing	4.75	28	0 day	00:00:00	23:59:60	15

Session Constraints:

Name	Scheduling constraints	Comments
HI Observing		

Session Source/Resource Pairs:

Session name	Source	Resource	Time
HI Observing	5066 5322 5609 5645	Redshifted HI	4.75 hour

Session name	Source	Resource	Time
	5814		
	6015		
	6363		
	6904		
	7847		
	7879		
	7935		
	8399		
	8455		
	8503		
	9391		
	9419		
	10030		
	10156		
	10244		
	10483		
	10592		
	11097		
	11128		
	11198		
	11260		
	11409		
	11470		
	646		
	1324		
	1993		
	2164		
	2353		
	2384		
	2561		
	3151		
	3232		
	3329		
	3376		
	3611		
	3634		
	3738		
	3770		
	3845		
	4133		
	4455		
	4481		
	4510		
	4614		
	4664		
	11478		
	11554		
	11560		
	11628		
	11758		
	11980		
	12071		
	12833		
	20503		
	21306		

Session name	Source	Resource	Time
	22318		
	22699		
	23036		
	23161		
	24007		
	24223		
	25281		
	26163		
	26706		
	26744		
	27869		
	27994		
	28275		
	28479		
	28561		
	28810		
	29563		
	29581		
	29613		
	29960		
	30270		
	32512		
	34954		
	35788		
	35810		
	36444		
	36498		
	36511		
	100038		
	100539		
	103059		
	105046		
	111609		
	111724		
	114578		
	116545		
	116546		
	120493		
	120570		
	121124		
	125371		
	125814		
	125815		
	125817		
	130214		
	131345		
	140442		
	151168		
	160387		
	160904		
	175126		
	180952		
	184750		
	190579		
	191474		

Session name	Source	Resource	Time
	194224		
	198643		
	200048		
	200208		
	201353		
	204628		
	204982		
	206431		
	207676		
	215538		
	219861		
	221146		
	222248		
	226495		
	229559		
	229560		
	231074		
	239288		
	239289		
	240937		
	256294		
	257439		
	260804		
	261094		
	270260		
	270462		
	272733		
	272734		
	272735		
	272736		
	272737		
	272738		
	272739		
	290421		
	300486		
	310069		
	310983		
	311262		
	311400		
	320249		
	321738		
	323628		
	323629		
	323630		
	323632		
	331536		
	337143		
	337144		
	400635		
	411448		
	411450		
	421112		
	421115		
	430063		
	430359		

Session name	Source	Resource	Time
	430428		
	430559		
	431482		
	431483		
	440420		
	440970		
	441221		
	450525		
	460003		
	460362		
	460363		
	480379		
	480381		
	490057		
	490064		
	490778		
	490781		
	500202		
	501715		
	501818		
	501819		
	510055		
	510089		
	520068		
	520167		
	520432		
	521469		
	530083		
	530277		
	531590		
	531591		
	531592		
	531593		
	540121		
	540155		
	540314		
	540932		
	550003		
	550056		
	550256		
	560035		
	610146		
	610773		
	610776		
	630248		
	630249		
	630346		
	630902		
	716159		
	723820		
	729972		

Technical Justification:

Dates:

NA

Observing time:

We plan to observe each source using position-switching for 15 minutes ON + 15 minutes off. We will be observing at L-band with a 23.44 MHz bandwidth, in dual polarization mode.

Smoothing to 9 km/s resolution, the sensitivity calculator yields a sensitivity of 1.5 mJy for a galaxy at 10000 km/s (characteristic velocity of our target galaxies) in ~1720s total time On/Off.

#####

Results

Derived Total Observing Time: 1.72e+03 s
 Time at Signal Position or Frequency: 858.28 s
 Time at Reference Position or Frequency: 858.28 s
 Effective Integration Time: 429.14 s
 Obs. Mode Time Mult. Factor: 2
 FWHM Beamwidth: 8.96 arcmin
 Aperture Efficiency: 0.71
 Extended Source Efficiency: 0.71
 Confusion Limit: 66.33 S (mJy)
 # Hrs Above Min Elevation: 9.43 hours
 Topocentric Frequency: 1375.131 MHz
 Min. Topocentric Channel Width: 0.045 kHz
 Desired Freq. or Vel. Resolution: 9.000000 km/s
 Typical Air Mass: 2.0
 Typical Atmospheric Attenuation: 1.014
 Typical System Temperature: 17.5 K
 Backend Sampling Efficiency (K1): 1.0000
 Backend Channel Weighting (K2): 1.0000
 Other Results
 Maximum Elevation: 51.6 d
 Pulsar Factor (bw / eff_bw * dc / (100.0 - dc)): 1.0000
 eta_surf: 1.00
 eta_track: 1.00
 n_ref_smth_avg: 1.000
 max_el_rad: 0.900
 Receiver Contribution to Tsys: 8.0 K
 Bandwidth of Reference Obs: 0.039950 MHz
 observing_method: 1
 eta_dss: 0.97
 Best Possible Atmos. Attenuation: 0.007 Nepers
 Topocentric Wavelength: 21.80 cm
 min_el_rad: 0.262
 dual_pol: 2
 Typical Effective Tsys: 17.7 K
 c2: 0.351580
 b: 2.000000
 Typical Atmospheric Opacity: 0.007 Nepers
 Source Diameter: 0.000 arcmin
 Typical Weighted Mean Temp. of Atmos.: 270.5 K
 Best Possible Effective Tsys: 17.5 K
 a: 62.751796 mK / (s^{0.5})
 Feed Taper: 13.0 db
 Approximate CMB: 2.7 K

Milky Way Contribution to Tsys: 0.0 K
 Reference Smoothing Factor: 1
 Speed of Light: 2.997925e+10 cm/s
 $k: 1.380650e-23 \text{ m}^2 \text{ kg} / (\text{K s}^2)$
 Approximate Spillover: 3.0 K
 Forward on-sky efficiency: 0.99
 Long-Wavelength Efficiency: 0.71
 Dish Radius: 50.0 m
 User Input
 Conversion: Sensitivity to Time
 Sensitivity Units: flux [mJy]
 User Desired Total Observing Time: 1.0
 User Desired Sensitivity (1-sigma): 1.5 mJy
 Backend: VErSatile GB Astronomical Spectrometer
 Mode: Spectral Line
 Receiver: L (1.15 - 1.73 GHz)
 Beams: 1
 Polarization: Dual
 Backend Total Bandwidth: 23.44 MHz
 Number of Spectral Windows: 1
 Switching Mode: Position Switching
 Reference Frame: Rest Frame
 Rest Frequency: 1421.0 MHz
 Doppler Correction: Optical
 Source Velocity: 10000.0 km/s
 Redshift: 0.0334 z
 Model for estimating background contribution to Tsys:
 User entered contribution to Tsys.
 Approximate Right Ascension: 0.0 hours
 Minimum Elevation: 15.0 d
 User Estimated Contribution to Tsys: 0.0 K
 Source Declination: 0.0 d
 Ratio of Signal Time vs Reference Time: 1.0 of RSigRef
 Number of Reference Observations: 1.0 of NAvrgRef
 Average Orthogonal Polarization: True
 Difference Signal: True
 Smoothing:
 Smooth to a Velocity Resolution in the Rest Frame.
 Desired Freq. or Vel. Resolution: 9.000000 km/s

Mapping:

NA

RFI considerations:

We are observing between 1340 and 1440 MHz. There is thus little expected RFI.

The only significant source of RFI is the GPS NUDET (~1381 MHz). We have existing IDL scripts (which have been adapted to GBT-IDL) for identifying integration-by-integration when that RFI is present, and will remove it as necessary.

Overhead:

The start of each session will have a single flux calibrator, which will be observed for 10 minutes, including the time to slew to the calibrator and change receivers to L-band.

With 220 sources, the 8 targets in a session will be chosen to cluster on the sky, minimizing slew time between observations. We estimate a typical slew time between sources to be 2-3 minutes.

For a 4.75 hour session with 30 minutes of integration per source, this would mean roughly 45 minutes of overhead, or 16% of the total session.

Joint considerations:

NA

Novel considerations:

NA

Pulsar considerations:

NA

LST Range Justification:

NA

The Baryonic Tully-Fisher Relation for Galaxies with Supernova Distances

Overview: The Baryonic Tully-Fisher Relation (BTFR), an empirical scaling relation that appears to link the baryonic mass of a disk galaxy to its rotational velocity, is used both to constrain models of how baryons inhabit their host halos and, of particular relevance to this proposal, to estimate galaxy distances. The comparison of redshifts expected for those estimated distances in pure Hubble flow with observed redshifts yields peculiar velocities which in turn can be used to probe the large-scale gravitational field. Using the BTFR to trace mass distributions requires a robustly determined template BTFR whose scatter is minimized, and well understood. Yet current templates are limited in their understanding of their uncertainties either due to small sample sizes or large distance uncertainties. Thus, we propose H I 21 cm line observations of 220 galaxies which have accurate distance measurements derived from the supernovae they host. These observations will allow for the construction of a well understood, minimal scatter template BTFR.

Scientific Justification: Tully & Fisher (1977) demonstrated the empirical relationship between the optical absolute magnitudes of galaxies and their global H I 21 cm line profile widths, the Tully-Fisher Relation (TFR), suggesting a direct connection between the stellar luminosity of a galaxy and the rotational velocity traced by the H I disk. While this relationship holds strongly for high luminosity galaxies, those with low stellar luminosities often fall away from the relation. Remarkably, McGaugh+ (2000) found the linear relation could be extended to the low stellar luminosity/mass end if the optical luminosity was replaced by the total baryonic mass (including both the stellar and gas mass), *i.e.*, the BTFR.

The BTFR scaling law is used principally for two distinct purposes: to set constraints on models and simulations of galaxy formation and evolution, and to determine redshift-independent distances. In this proposal, we focus on the latter application, specifically as it can be used to measure peculiar velocities. In the local Universe, observed recessional velocities of galaxies can deviate significantly from the Hubble flow due to the gravitational influence of nearby, large-scale structures. By comparing observed recessional velocities with those expected based on distances estimated from the BTFR, the perturbing gravitational masses can be located and their overdensities quantified. **Of particular note, we are attempting to measure the infall onto the Pisces-Perseus Supercluster (PPS) filament (*e.g.*, O’Donoghue+ 2019) by comparing the observational BTFR for rotationally-dominated galaxies in the vicinity of the supercluster to a template relation.** The derived peculiar velocities will then be compared with those predicted by numerical simulations to yield an estimate of the mass per unit length along the PPS filament.

In practice, the BTFR employs several observationally-derived quantities whose uncertainties contribute to the challenge of defining a representative template relation. Determining the baryonic mass of a galaxy requires an estimate of the stellar mass as well as the gas mass. Numerous prescriptions for estimating the stellar mass from photometric properties using public databases in the optical/infrared bands exist, *e.g.*, Durbala+ (2020). It should be noted that different approaches produce rather different results especially at the high and low mass ends and rely on assumptions about star formation history and extinction corrections (due to the Milky Way and internal to the host) which can differ substantially depending on the galaxy population being probed. The gas mass is derived directly from the integrated H I line flux and adjusting for the cosmic abundance of helium.

The challenge with the BTFR as a distance indicator is to derive a template relation that can be used as a comparison with the relation observed for the peculiar velocity sample and with the results

predicted by numerical simulations of infall onto mass overdensities. For TF/BTF applications for large samples of galaxies, the disk rotational velocity is usually derived from the width of the H I 21-cm profile, corrected for inclination and redshift stretch. For smaller samples of galaxies for which the H I distribution is resolved, rotational velocities can be derived from resolved H I rotation curves. As discussed *e.g.*, by Bradford+ (2016) and Lelli+ (2019), different definitions of velocity width can induce systematic differences in BTFR fits. Recent work by our group (Ball & Haynes 2020, Ball+ 2021, Gomez Barrientos+ 2021, Letai+ 2021) has focused on testing best methods of measuring the velocity width from global H I line profiles with particular attention to quantifying the uncertainties in peculiar velocity measurements.

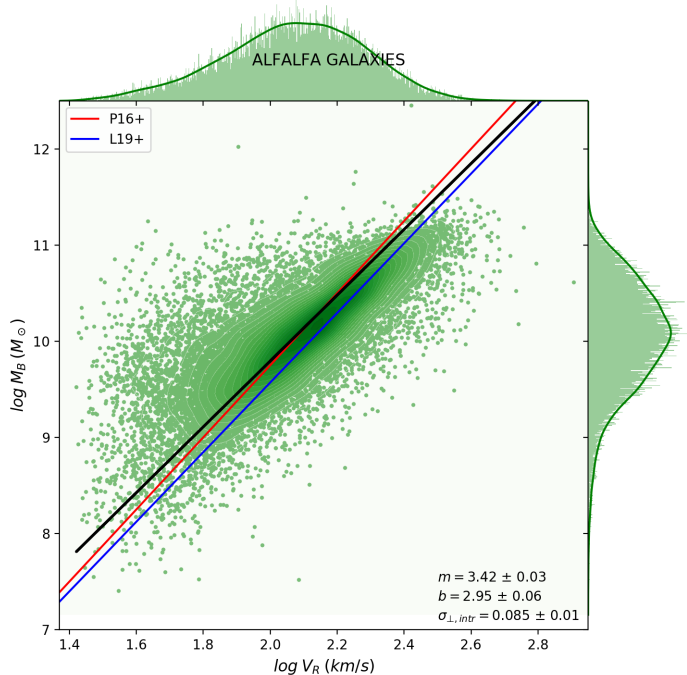
A commonly-used method to derive a template relation employs the “basket of clusters” technique, *e.g.*, Giovanelli+ (1997), Masters+ (2008), Kourkchi+ (2020). Note that all these provide template TFRs, not BTFRs. Recent calibrations of the BTFR, *e.g.*, McGaugh 2005, Papastergis+ (2016), Lelli+ (2019), Schombert+ (2020) have used relatively small samples which can be significantly impacted by distance uncertainties. The distribution of data in both the velocity and mass dimensions, the method of fitting, and treatment of uncertainties also prove critically important. Figure 1 shows the BTFR derived for the highest quality data from the ALFALFA Survey (Haynes+ 2018). In this analysis, stellar masses for the ALFALFA galaxies have been derived following Durbala+ 2020. Figure 1 is the Log-Log plot of rotational velocity derived from the global H I line width and the baryonic mass with the best fit line (black), and the template BTFRs from Papstergis+ 2016 (red) and Lelli+ 2019 (blue) superimposed. The large scatter and offsets show the need to derive a better BTFR template if it is to be used to determine distances to galaxies within the PPS. As the motivation for this proposal, we suggest an alternative approach: to derive a template using a robust sample of galaxies spanning the full range of masses characteristic of rotationally-dominated disks for which accurate distances are available from primary techniques. For nearer distances, primary distances from resolved stars (Cepheids, tip of the red giant branch, etc; Anand+ 2021) can be used. At larger distances, probing larger volumes, however, SNe host galaxies provide the appropriate reference sample. For the most accurate peculiar velocity measurements, careful attention must be made to all contributions to uncertainty. **Our aim is to derive a template BTFR from a sample for which accurate distances, sufficient photometry, and digital global H I line profiles are available.** We will make use of existing data where possible, but here we seek to obtain H I profiles of galaxies with supernova distances for which digital spectra are not available.

Sample Selection and Expected Detection Statistics: The need for galaxies with precise, redshift-independent distance estimates naturally leads us to explore the galaxy hosts of known SNe in the local universe. The Democratic Samples of Supernovae (DSS, Stahl+ 2021) is the most comprehensive sample of local supernovae to date, consisting of 765 SNeIa and Type II supernovae (SNeII), with well-known distances. The DSS serves as our starting point for identifying our observing sample. First we cross-matched the DSS with the Extragalactic Distance Database (EDD, Tully+ 2009), identifying host galaxies for 661 of the 667 SNeIa. Next, we cross-matched the remaining DSS entries with the NASA/IPAC Extragalactic Database (NED¹), identifying host galaxies for all but one of the 98 SNeII. These 758 host galaxies comprised our initial galaxy sample.

To arrive at the sample proposed here, we applied several technically or physically-motivated cuts to the initial sample. First, we require galaxies be visible from Green Bank (Decl. > -40 deg.) and at velocities consistent with the completeness of the ALFALFA survey ($cz < 15000 \text{ km s}^{-1}$). We

¹The NASA/IPAC Extragalactic Database (NED) is funded by the National Aeronautics and Space Administration and operated by the California Institute of Technology.

Figure 1: Preliminary results of the BTFR for the highest quality ALFALFA sample. Observational properties come from the catalogs of Haynes+ (2018) and Durbala+ (2020). The template BTFRs from Papastergis+ (2016) and Lelli+ (2019) are shown along with the best fit (black line) to the ALFALFA data using a maximum likelihood fitting method with full accounting of uncertainties. The large scatter and offsets emphasize the need to derive a better template relation that samples the full range of rotationally dominated galaxies and minimizes scatter in the distance-dependent direction. From Gomez Barrientos+ (2021).



then cross-matched the initial sample with the Arecibo General Catalog (AGC) to identify galaxies with known HI-related properties, indicating available archival digital spectra of HI observations. We remove all host galaxies with retrievable archival HI spectra *e.g.*, Springob+ (2005); Masters+ (2014, 2019), Stark+ (2021), where the $S/N > 10$ (as well as all robust non-detections in the archival HI observations), as the data quality is high enough to allow for the detailed spectral analysis of our robust analysis pipeline.

Given that we are attempting to observe the HI 21-cm emission line, we next cut all objects with RC3 Type $T < 0$ (as taken from the EDD), which classifies the galaxies as ellipticals. Furthermore, for our proposed observations to be useful in contributing to a BTFR template, the width of the observed emission profile must be corrected for projection/inclination effects. As the orientation of the galaxy approaches face-on, these corrections become so extreme that they become the dominant cause of scatter in the BTFR. To minimize this inclination effect, we cut any galaxy with an axial ratio $b/a > 0.80$. Last, we searched online databases, including SDSS and CDS, to identify (and remove) potential confusion in the beam from other galaxies nearby in both angular separation and velocity-space, removing galaxies from our sample with a non-elliptical neighbor within $\sim 10'$ and $\sim 300 \text{ km s}^{-1}$. Having removed these galaxies from our prospective sample, we are left with 220 SNe host galaxies to consider for observation.

Of these 220 SNe host galaxies which comprise our proposed sample (see Figure 2 for the redshift/distance distribution of the sample), 127 have no known HI observations, 50 have known HI properties but no accessible HI spectral data, and 43 have HI spectral data below our quality cut of $S/N > 10$. In addition, there are 128 galaxies with accessible high-quality, archival digital spectra, which we will also analyze, expanding our total statistical sample to 348 galaxies. Combining the proposed sensitivity of $\sim 1.5 \text{ mJy}$ per channel (see below for details) for each observation with the well-constrained distances for each galaxy allows us to achieve HI-mass sensitivities equivalent to

the ALFALFA survey over the entire velocity range probed.

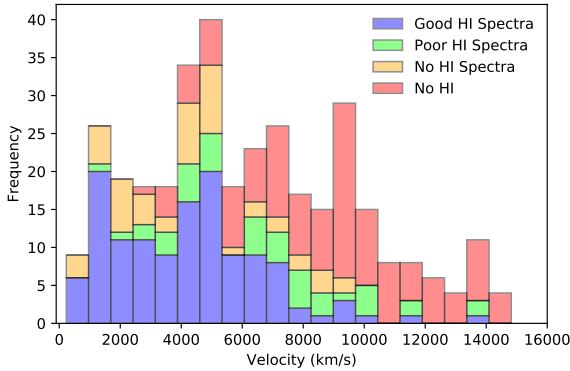


Figure 2: A histogram showing the velocity distribution of the proposed targets along with the archival sample. The blue data are galaxies with high-quality archival data that we will not observe (but will analyze as part of our sample). We will observe the galaxies with low-quality, archival H I spectra in green, the galaxies that have no available archival H I spectra in orange, and the galaxies that have no known H I observations or H I properties in red.

Observing Request: We request a total of 133 hours, including overhead, to observe 220 targets. We will observe using a similar approach to the strategy highlighted in Masters+ (2019) and used for the H I-MaNGA observing program at the GBT. Our strategy consists of a standard total-power position-switching mode, observing in iterative 5 minute ON-OFF pairs until the source is detected with sufficient signal-to-noise ratio (SNR) or a total of 15 minutes ON and 15 minutes OFF per source yielding a ~ 1.5 mJy rms in 9 km s^{-1} channels. With this approach, we will achieve mass and S/N limits comparable to the galaxies with good HI spectra at comparable distances. Including overhead, we thus estimate a rate of ~ 8 sources per 4.75 hour observing block. With the collapse of the Arecibo telescope, the GBT is the only viable facility to use for this program.

As in our previous observing program (GBT/19A-240), undergraduate students and faculty in the Undergraduate ALFALFA Team (UAT²) will be heavily involved, conducting observations remotely and analyzing data. Note several co-authors on this proposal are current undergraduate students. All of the reduced spectral data from this program will be made publicly available on the UAT website.

We request 4.75 hours of the proposed program be assigned during summer 2022 when UAT members will be onsite for the annual UAT workshop (exact date being discussed with GBO staff). All other observations can be performed in any operational weather conditions.

References:

- | | |
|---|---|
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²egg.astro.cornell.edu/alfalfa/ugradteam/gbt.uatlist.html