The SEBs jet in 2012/13.

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(In this report, 'fast' means rapidly retrograding.)

In autumn 2012, most of the spots on the SEBs were retrograding remarkably fast, according to analysis of the JUPOS data by G. Adamoli (**Table).** The mean speed was DL2 = +150.8 deg/mth (u_3 = -72.3 m/s); maximum +165 deg/mth (u_3 = -79 m/s). These exceptional speeds are beyond doubt. The relevant spots were widely separated in time and longitude. Even if the two fastest were discarded as outliers, there would still be four well-determined tracks with DL2 ~ 145 (±3) deg/mth (u_3 = -69.7 [±1.5] m/s), far beyond the usual speed. The speeds of some have been independently measured by JHR, with consistent results; also a ZWP from HST images (see below) showed u_3 = -69.5 m/s in the relevant sector. The images also show similar spots which were not bright enough to be tracked but had much the same motions.

The fast spots were tiny white spots, indenting the SEBs edge. Although they were tracked singly, some if not most were part of short wave-trains, and the same images showed other such spots which were less conspicuous. The best maps from autumn 2012 showed that small-scale waves like these were common in this latitude [see Fig.3 in our 2012/13 Report no.9: http://www.britastro.org/jupiter/2012_13report09.htm]. Examples are shown in **Fig.S8**. Spot w3 was tracked singly but HST images (see below) showed it was actually part of a subtle wave-train. Spot w7 was the first in a train of 3-4 white spots with wavelength 5-7º, after an earlier leading spot faded away. The wave-train that included w7 has been re-measured by JHR **(Fig.S8-inset)**, confirming a speed of DL2 ~ +148 deg/mth for w7 overall but finding an even faster speed, +167 deg/mth, for most of its track and for the associated wave-train. These waves were not moving more slowly than the jet (contrary to the situation in 2011).

The very fast speed in autumn 2012 is confirmed by reference to zonal wind profiles (ZWPs) produced by M. Vedovato from the HST images taken over 3 rotations on 2012 Sep.20 (**Fig.S9**). In one sector, ~30-140º p. the GRS, the peak speed was -69.5 (±0.5) m/s, at 19.7ºS. This is close to our fast speed, and the lower latitude probably represents the sinuous true edge of the SEBs, rather than the white spots to its south which we measured. However, this speed was not seen in two other sectors, nor in a global average ZWP produced independently by G. Hahn, which show only the typical peak with u ~ -59 m/s; likewise, Hahn's ZWPs from amateur images show u ~ -51 m/s in 2012 Sep-Dec. [Fig.20 of Ref.1]. Therefore, the very fast speed was not detectable at all longitudes or times.

The HST images of 2012 Sep.20 (**Fig.S9**) showed one of our spots (w3), which was approaching the GRS; it rapidly elongated over the 3 rotations covered. (We do not know whether it survived to reach the GRS, as there was then a gap in our obs'ns.) Trailing behind it was a series of 3 shallow waves (wavelength 4.2º), followed by another wave-train (5 waves, wavelength 4º-7º), all at 19-20ºS, which were probably the features represented in the ZWP: they clearly resemble the wavetrain which we tracked behind spot w7 (compare **Figs. S8 & S9**). In other sectors, which do not show the high speed in the ZWP, there are no such waves, but the rifted region f. the GRS gives rise to roughly chevron-shaped streaks which evolve into dark patches in the identical latitude, confirming that this is the peak of the jet.

Table: SEBs jet spots in 2012/13 (white spots)

spot	time interval	ΔL2(°/30d)	U3(m/s)	lat.	SD	N	notes
W1	2012 Aug 8 - 18	147,3	-70,9	-19,8	0,50	7	
W2	Jul 22 - Aug 6	144,2	-69,2	-20,4	0,65	7	
W3	Sep 9 - 19	165,1	-78,7	-20,4	0,14	10	See figure.
W4	Nov 14 - Dec 9	141,0	-67,9	-20,2	0,47	11	
W7	Nov 18 - 28	148,0	-70,9	-20,4	0,23	7	See figure.
W8	Oct 25 - Nov 14	159,2	-76,2	-20,3	0,21	7	
	Mean	150,8	-72,3	-20,3			
	SD	9,3	4,2	0,23			
W12	2012 Sep 3 - 13	115,0	-55,7	-20,9	0,51	6	F. GRS
W10	Nov 29 - Jan 5	120,7	-58,4	-20,7	0,46	17	
W11	2013 Feb 6 - 19	125,1	-60,5	-20,5	0,47	6	F. GRS
	Mean	120,3	-58,2	-20,7			
	SD	5,1	2,4	0,20			

Similar small white spots had been recorded in 2011/12, but without these rapid speeds. In 2011 Aug-Sep. a remarkable overlap of wave-trains was taking place: the white spots (DL2 ~ +132 deg/mth, spaced ~12º apart) coexisted with a wave pattern of dark humps (DL2 ~ +39 deg/mth, spaced ~10º apart), all at 20-21ºS. (This is described in detail in our final report for 2011/12: Ref.2).

Discussion: Acceleration of the SEBs jet, or a novel type of wave?

There is no precedent for the very fast speed in autumn 2012, except when a S. Tropical Disturbance or Dislocation was present. The last time such a rapid speed was detected was in 1993 (when we tracked one spot with DL2 = +145; BAA unpublished report). Since then the mean speed has never been greater than +131 deg/mth (up to 2011, inc. unpublished JUPOS data). The fastest SEBs peak speed in spacecraft ZWPs was +133 deg/mth from New Horizons.

Thus the very rapid speeds in late 2012 seem to indicate an anomalous condition of the SEBs jet, although there was no visible abnormality to account for it. As most or all of these rapidly-moving spots were embedded in wave-trains, it is possible that the speeds were actually phase speeds for wave-trains that were faster than the jet wind speed. This situation has been observed on Saturn by Cassini, as a 'string of pearls' on a retrograde jet [Refs.4 & 5].

References:

1. Rogers J, Adamoli G, Hahn G, Jacquesson M, Vedovato M, & Mettig H-J (2013). 'Jupiter's South Temperate domain: Behaviour of long-lived features and jets, 2001-2012.' http://www.britastro.org/jupiter/stemp2013.htm

2. Rogers J & Adamoli G (2015), 'Jupiter in 2011/12: Final report up to 2012 Feb.' http://www.britastro.org/jupiter/2011report09.htm

3. Vedovato M, 'Jupiter: maps from HST 2012 September 20'. http://pianeti.uai.it/index.php/Jupiter:_maps_from_HST_2012_September_20 The HST images were taken on 2012 Sep.20 by an international team headed by Dr Glenn Schneider (University of Arizona) and Dr Jay Pasachoff (Williams College and Caltech), as part of their project to detect the transit of Venus that was then visible from Jupiter.

4. Sayanagi KM, Dyudina UA, Ewald SP, Muro GD & Ingersoll AP (2014). 'Cassini ISS observation of Saturn's String of Pearls.' Icarus 229, 170–180.

5. Baines KH, Fletcher LN, Momary TW, Showman AP, Irwin PGJ, Brown RH, Buratti BJ, Clark RN, Nicholson PD & Sotin C (2013) 'The evolution of Saturn's string of pearls over five years as revealed by Cassini/VIMS.' *Preprint submitted to Icarus.*

Figure legends:

Fig. S8. Images of SEBs jet spots in 2012/13, approaching and encountering the Red Spot Hollow: w3 and w7 and associated wave-trains. *Inset:* Chart to track the wave-train that included w7. The whole wave-train moves with DL2 = +167 deg/mth, although slower motion for the early part of the w7 track accounts for its average motion of ~+148 deg/mth in the Table.

Fig. S9. Analysis of HST images taken on 2012 Sep.20 (the 'Transit of Venus' set by G. Schneider et al.), reproduced from Fig.19 of Ref.1 on larger scales. ZWPs were produced in 4 longitude sectors by M. Vedovato [Ref.3].
(A) The HST map (in L3), showing the 4 sectors analysed.
(B) The ZWPs for southern hemisphere as published in Ref.1.
(C) The HST map (in L2) at full scale, with two wave-trains in the SEBs indicated, including spot w3.
(D) The ZWPs at larger scale.
(E) Table of the speed and latitude of the SEBs jet peak in each sector.
Note that sector 2 (green curves in ZWPs) has a rapid speed agreeing with our JUPOS results.