Ultralow-Frequency Waves in Driving Jovian Aurorae Revealed by Observations from HST and Juno

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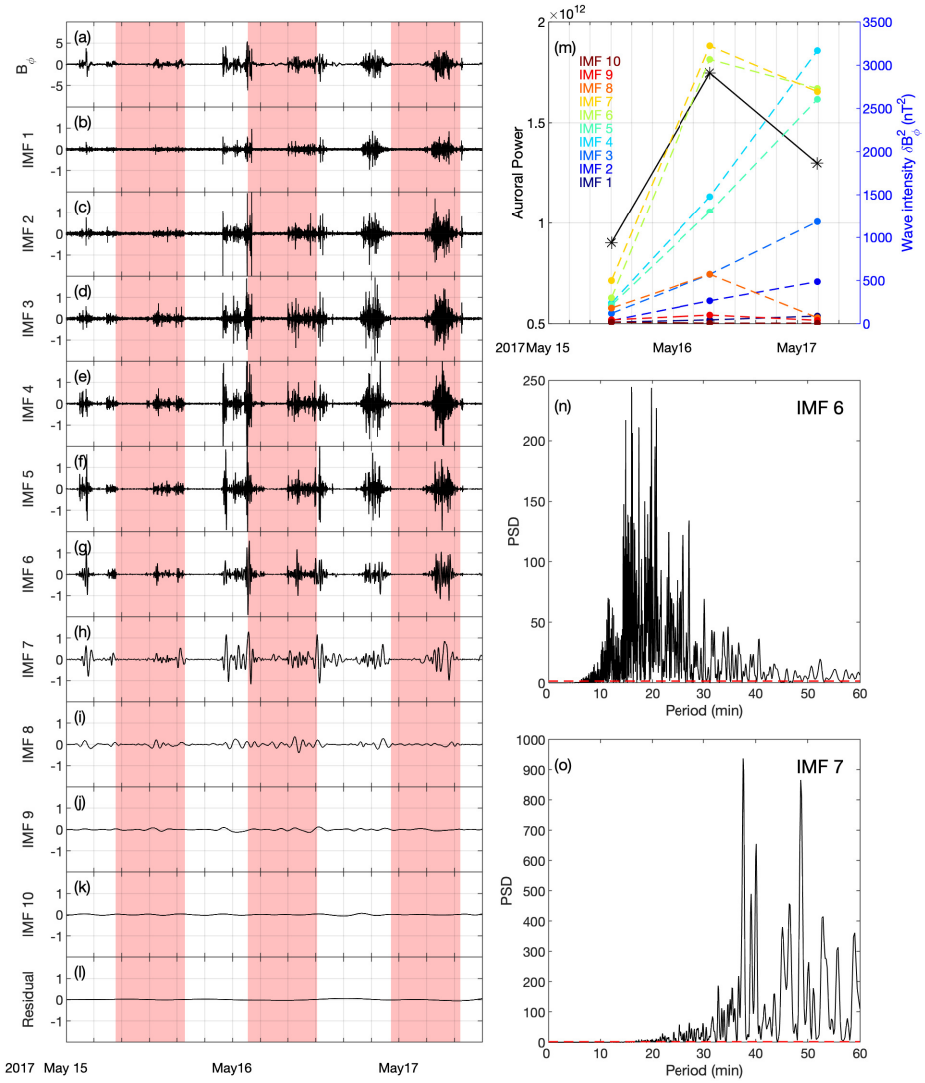

Figure S1. Application of empirical mode decomposition (EMD) method to the Juno MAG data wave analysis. (a) Magnetic field B_ϕ component (in FAC coordinates); (b-l) intrinsic mode functions (IMF) obtained from empirical mode decomposition; (m) total auroral power from HST (black stars) and wave intensity of δB for different components (color dots); (n-o) Lomb-Scargle analysis for IMF 6, IMF 7. The red dashed lines are the power-level threshold consistent with probabilities of detection equal to 0.95.

The Hilbert-Huang Transform (HHT) has been proposed to be useful in several fields (Huang & Wu, 2008). The key part of HHT analysis is empirical mode decomposition (EMD) method. Such a self-adaptation method is particularly useful in resolving nonlinear signals, decomposing pulsations into finite intrinsic modes (IMF). Kataoka, Miyoshi, and Morioka (2009) introduced HHT analysis to geomagnetic pulsations analysis, which works well in identifying Pi1, Pc3 and Pi2 magnetic fluctuations at auroral expansion onset. Here, we apply EMD method to electromagnetic fluctuations at Jovian magnetosphere. Figure S1 shows an example for EMD method in wave analysis at Jupiter. By decomposing magnetic field B_ϕ component (in FAC coordinate shown in Figure S1a) using EMD method, we obtain 10 intrinsic modes. The original signal can be reproduced by adding all intrinsic modes up, as well as residual (shown in Figure S1l). We also present total auroral power from HST and the comparision with wave intensity of δB for different components (shown as color dots in Figure S1m). The auroral power is well correlated with IMF 6 (10-30 min) and IMF 7 (30-60 min) modes, which include the major perturbations as our bandpass filter (Figure 2). The automated wave decomposition by EMD is thus proven to be applicable for ULF wave analysis in Jupiter's magnetosphere. Moreover, the results show that the 1-10 min perturbations are not a major contribution in auroral processes. Since the HHT method can well address time-frequency analysis, it may be applied in other space perturbations, particularly on the signals with frequency shift like X-ray pulsations from Jovian polar auroral region (Dunn et al., 2016).

References

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Table S1. List of 16 HST visits for statistical analysis

Event No.	HST time (yyyy-mm-dd/HH:MM:SS)
1	2016-12-02/17:03:31
2	2016-12-02/18:38:54
3	2016-12-08/11:21:03
4	2017-01-26/18:04:03
5	2017-01-27/13:08:24
6	2017-01-29/14:24:36
7	2017-03-19/09:57:00
8	2017-03-22/07:53:33
9	2017-05-10/11:19:00
10	2017-05-10/12:53:47
11	2017-05-11/07:58:51
12	2017-05-15/12:06:56
13	2017-05-16/07:11:14
14	2017-05-17/03:50:55
15	2017-07-04/02:38:03
16	2017-07-08/06:46:16