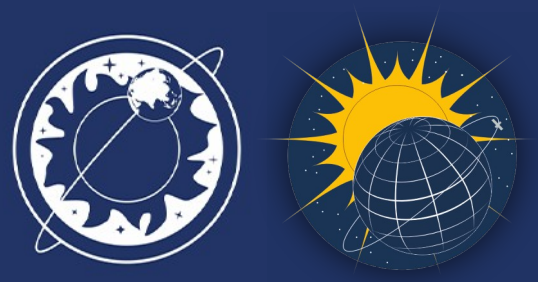

THE 15TH RUSSIAN-CHINESE WORKSHOP ON SPACE WEATHER
September 9-13, 2024, Irkutsk, Russia

EXPERIMENTAL CONFIRMATION OF THE EXISTENCE OF A NEAR-EQUATORIAL RESONATOR FOR MAGNETOSPHERIC ION-ION HYBRID MODES

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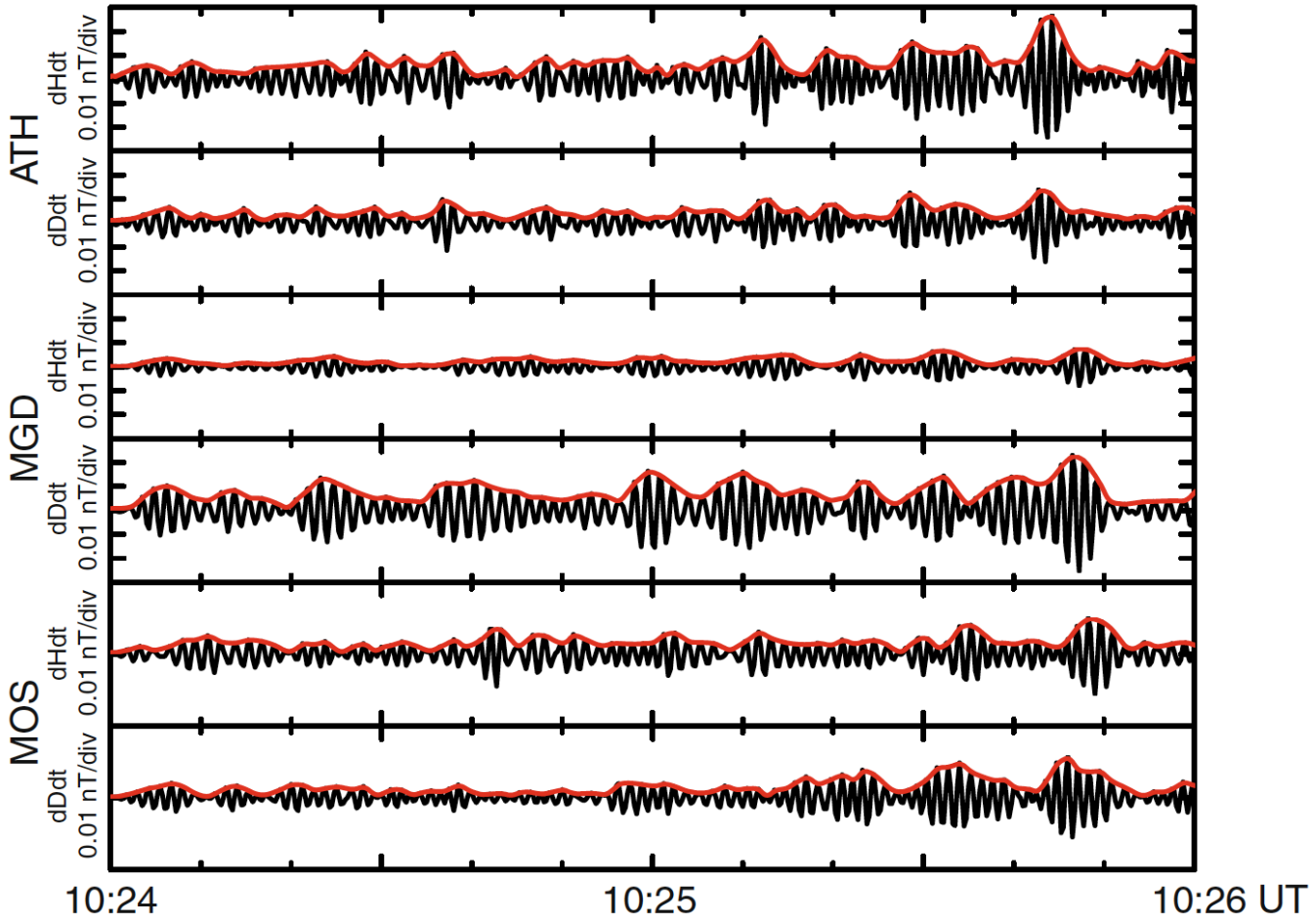
The research was financially supported by the Russian Science Foundation under Grant No. 22-77-10032.

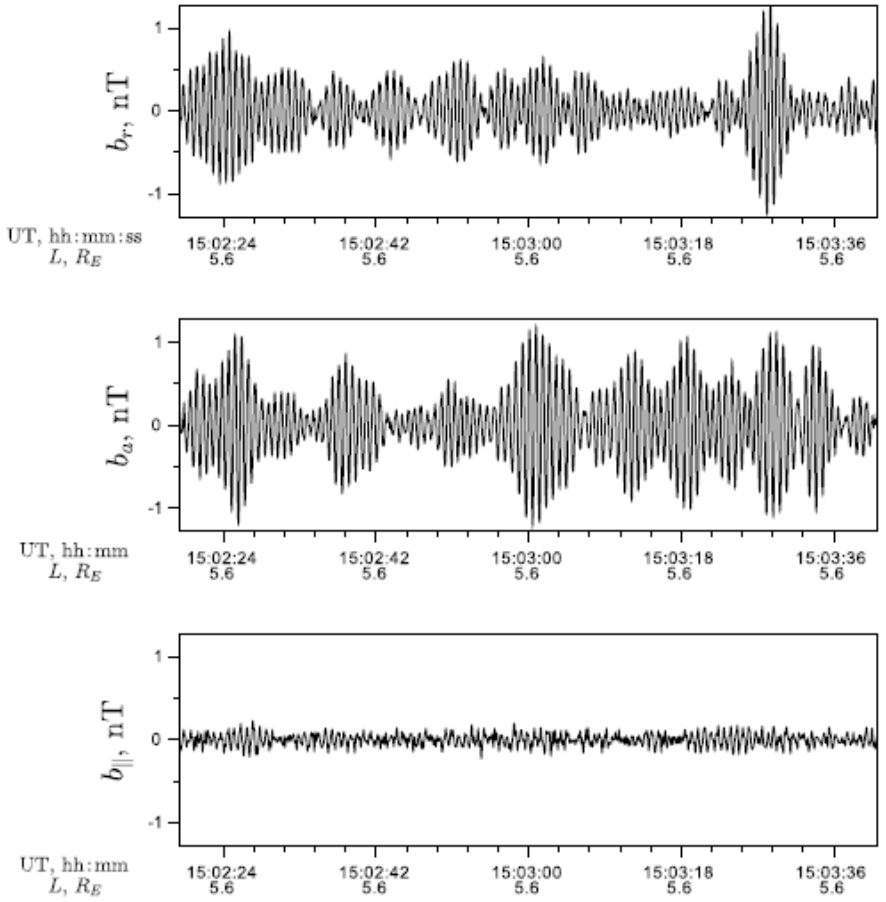
PC1 PULSATIONS

April 8, 2010



Jun et al., 2014

14 July, 2014, Van Allen Probe A



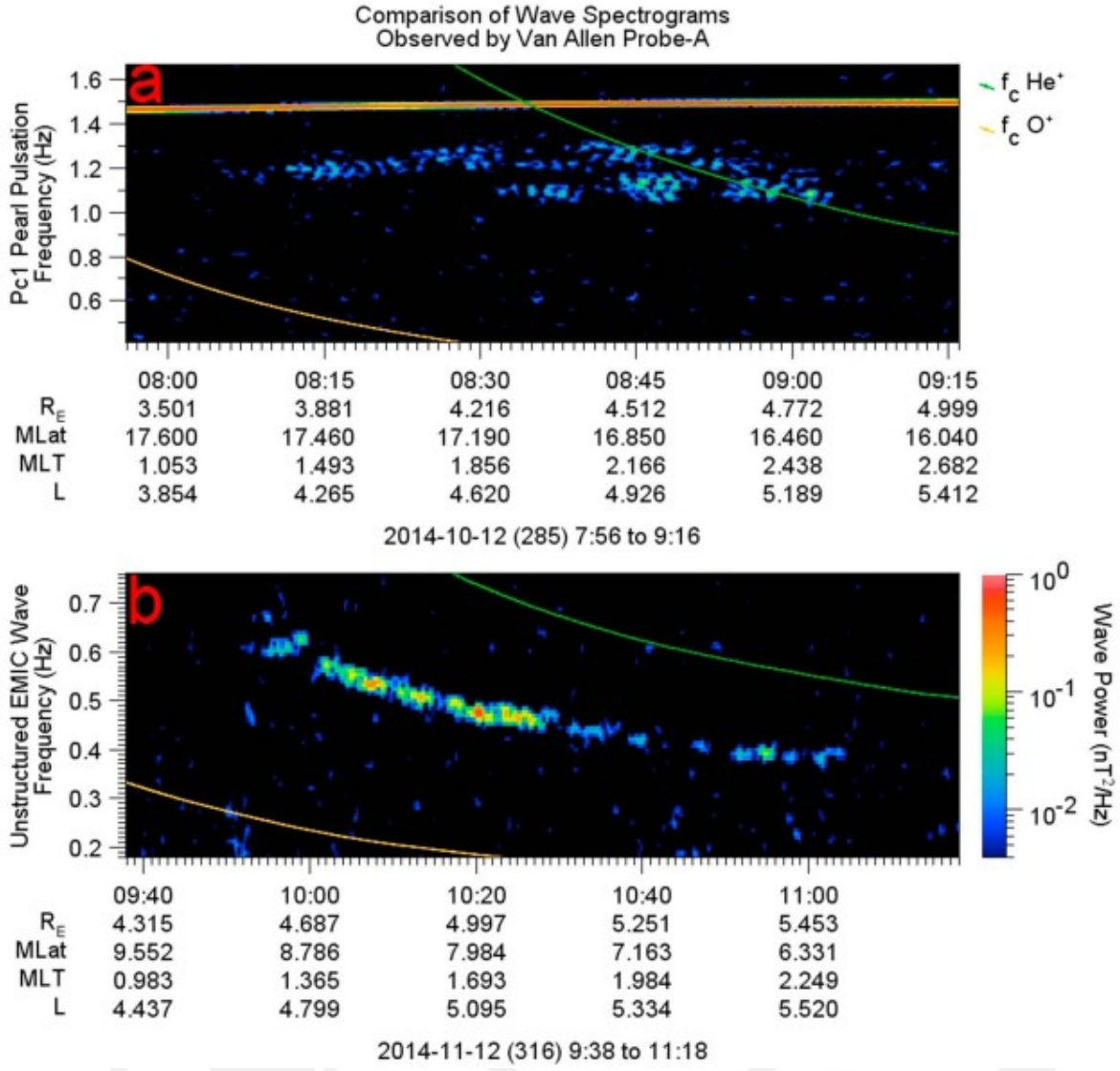
PC1 PULSATIONS

- Linear polarized waves – **ion-ion hybrid waves,** occur in plasma with the admixture of heavy ions

$$k_\perp \gg k_\parallel$$

- Left circular polarized waves – **electromagnetic ion-cyclotron waves (EMIC)**, occur due to ion-cyclotron instability

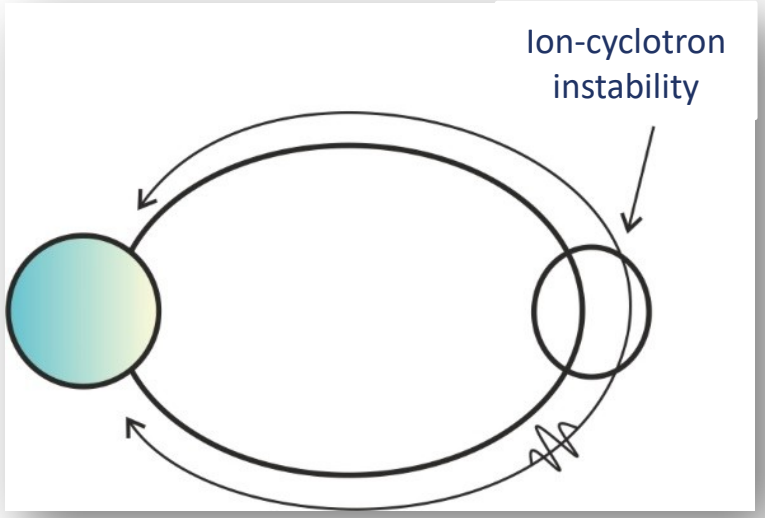
$$k_\perp \ll k_\parallel$$

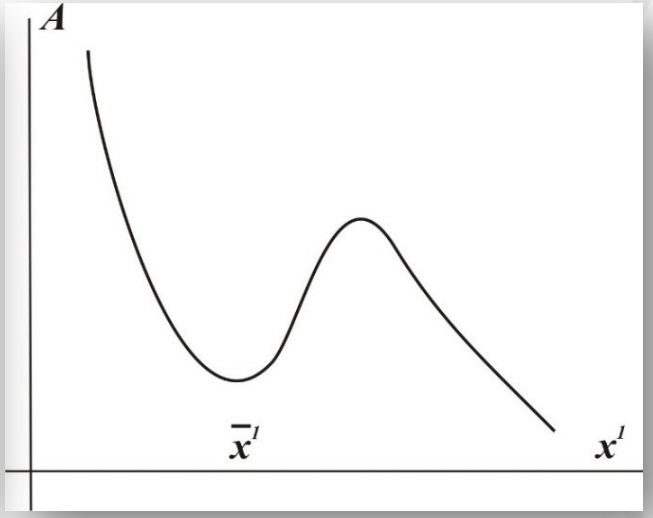


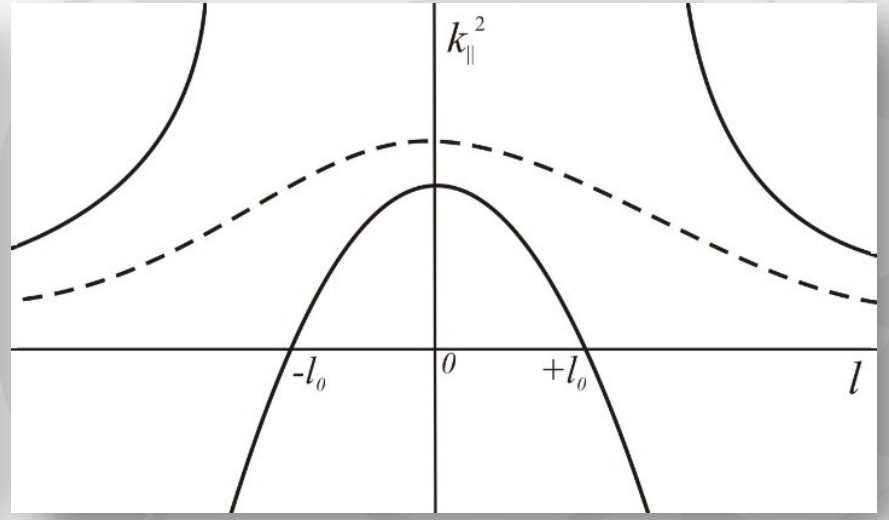
Paulson et al., 2017

MODELS

- Bouncing wave packet [Jacobs and Watanabe, 1964; Obayashi, 1965].
- Transverse resonator at the plasmapause [Dmitrienko and Mazur, 1992]
- Modulations by Pc4-5 [Mursula, 2007]
- Longitudinal resonator for ion-cyclotron waves in plasma with heavy ions [Guglielmi et al., 2000]
- Longitudinal resonator for ion-ion hybrid waves in plasma with heavy ions [Klimushkin et al., 2010]







NEAR-EQUATORIAL RESONATOR FOR ION-ION HYBRID MODES

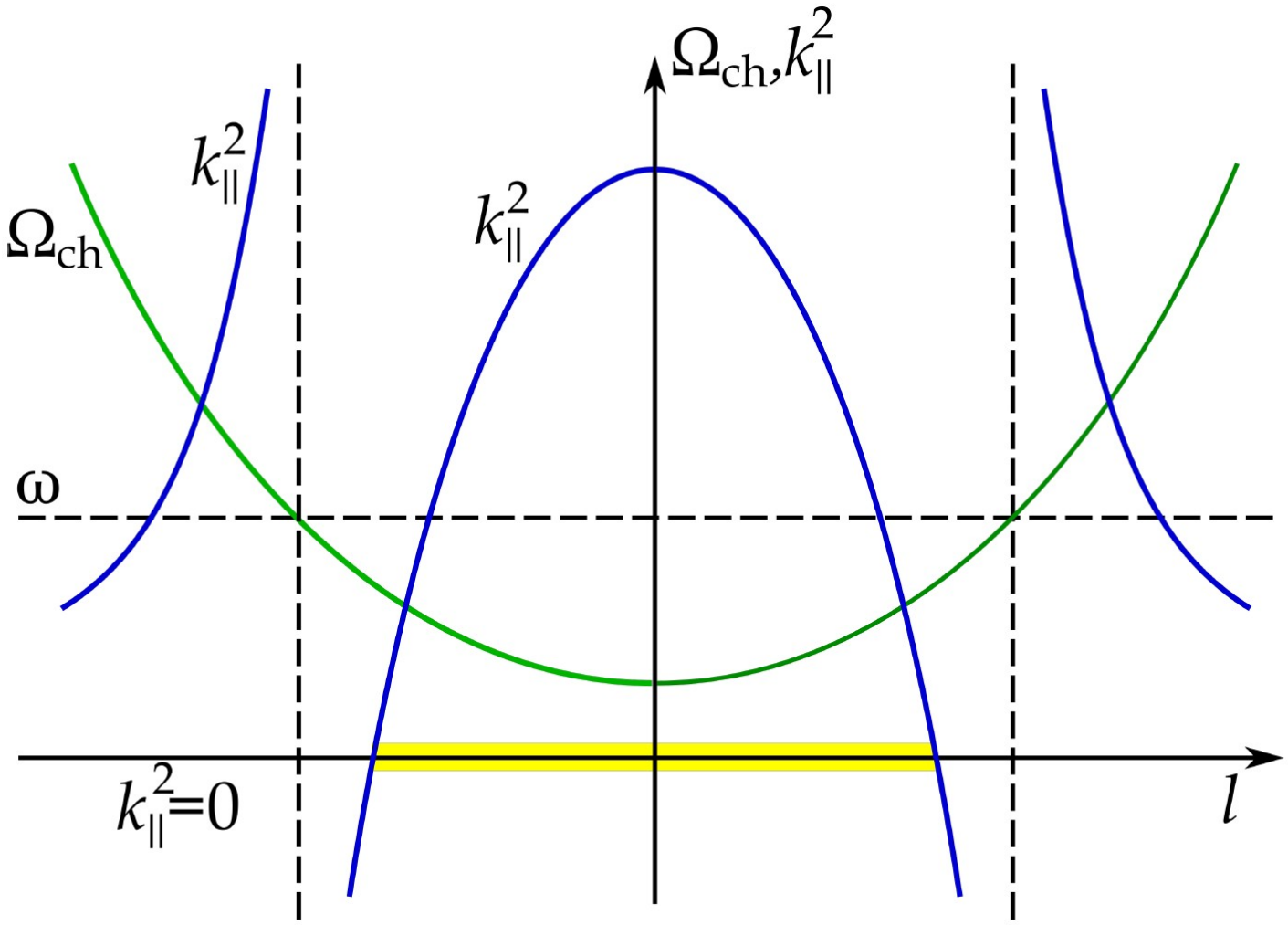
$$k_{\parallel}^2 = \frac{\omega^2}{A_p^2\left(1-\frac{\omega^2}{\Omega_{cp}^2}\right)} + \frac{\omega^2}{A_h^2\left(1-\frac{\omega^2}{\Omega_{ch}^2}\right)}$$

$$A_{p,h} = \frac{B_0}{\sqrt{4\pi n_{p,h} m_{p,h}}}$$

Turning points

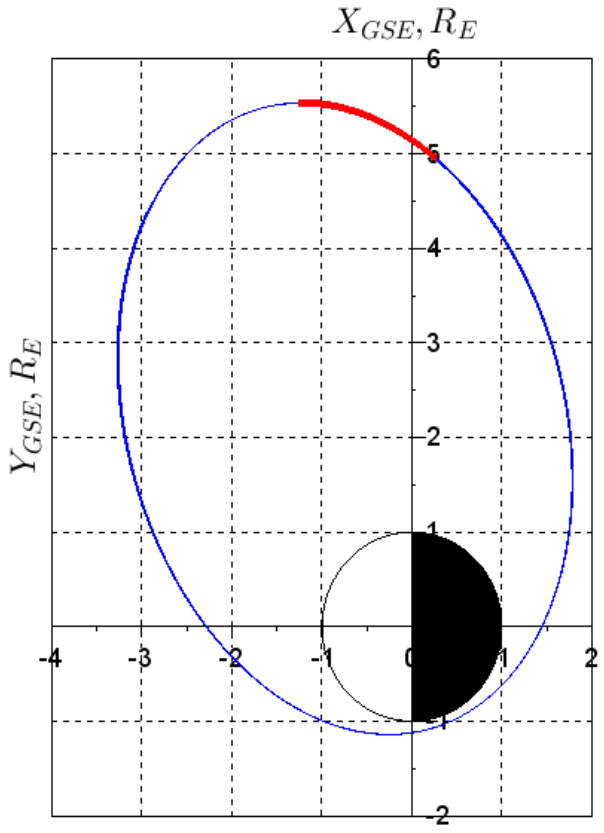
$$\Omega_0 = \Omega_{ch}\sqrt{\frac{\frac{\rho_p}{\rho_h}+1}{\frac{\rho_p}{\rho_h}+\frac{m_p^2}{m_h^2}}}$$

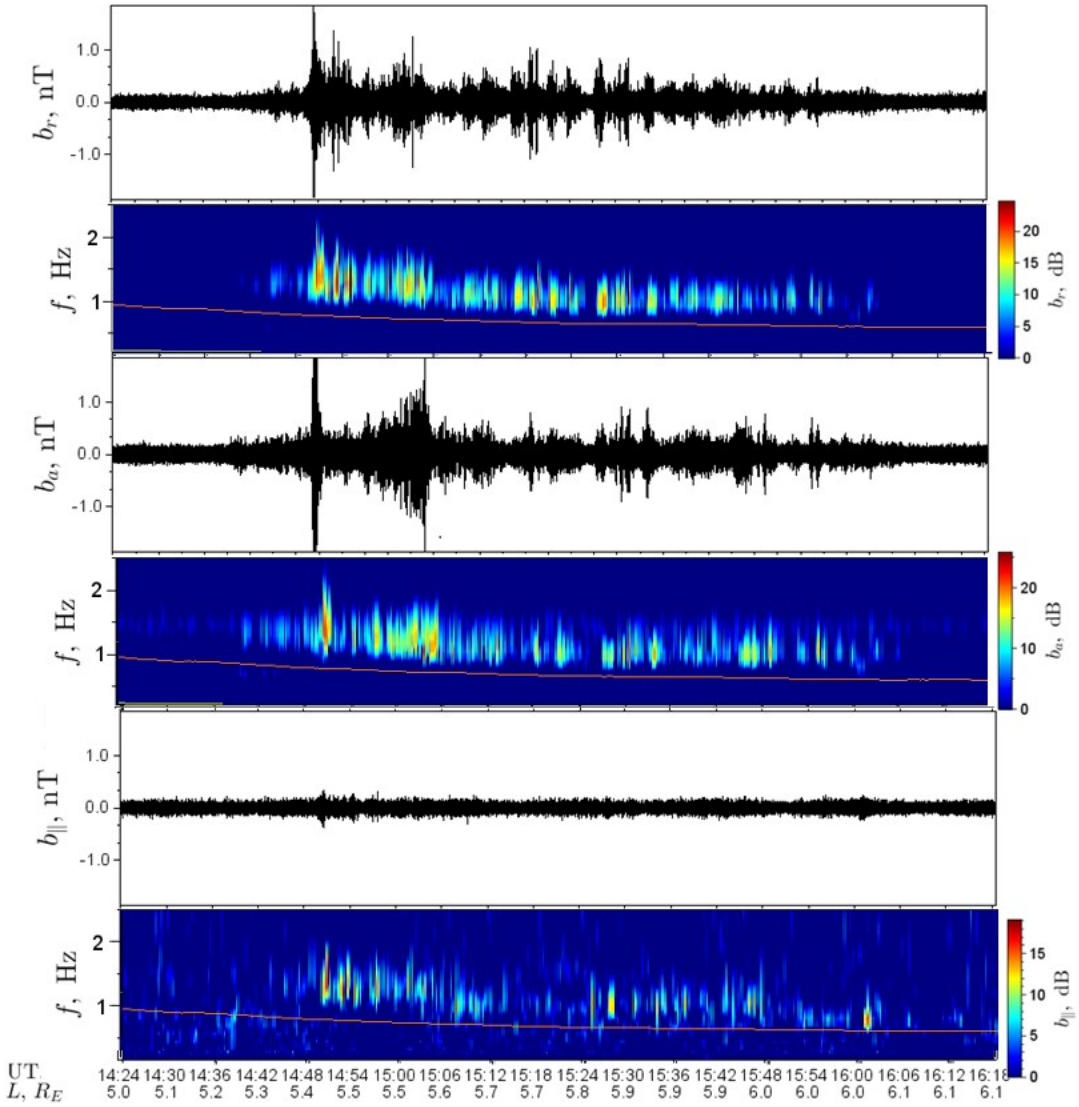
$$\omega_n^2 = \left(1+\frac{\rho_h}{\rho_p}\right)\Omega_{ch}^2 + (2n+1)\frac{\rho_h}{\rho_p}\frac{A_h\Omega_{ch}}{r_{eq}}$$



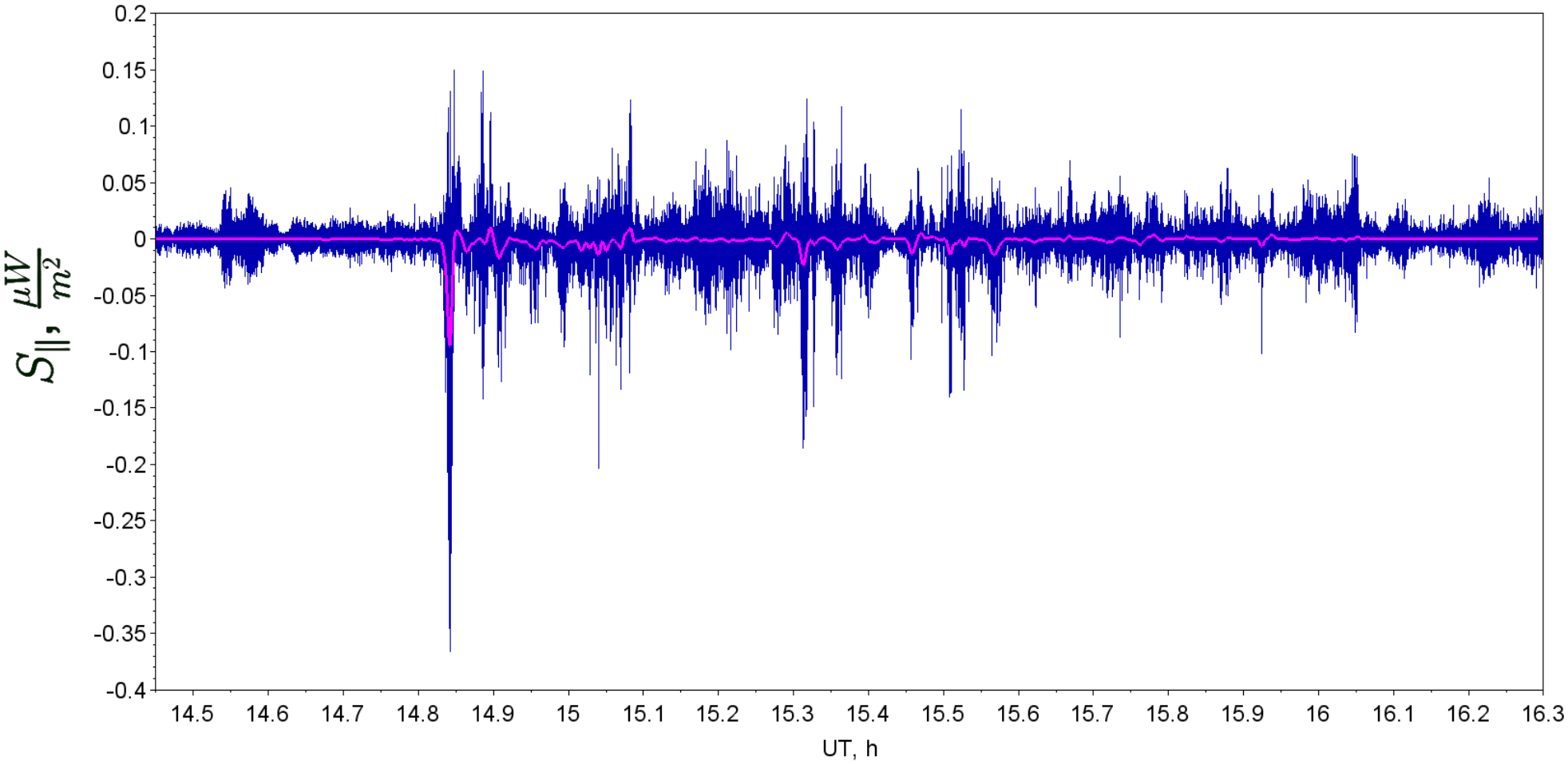
PC1 EVENT

14 July, 2014
Van Allen Probe A

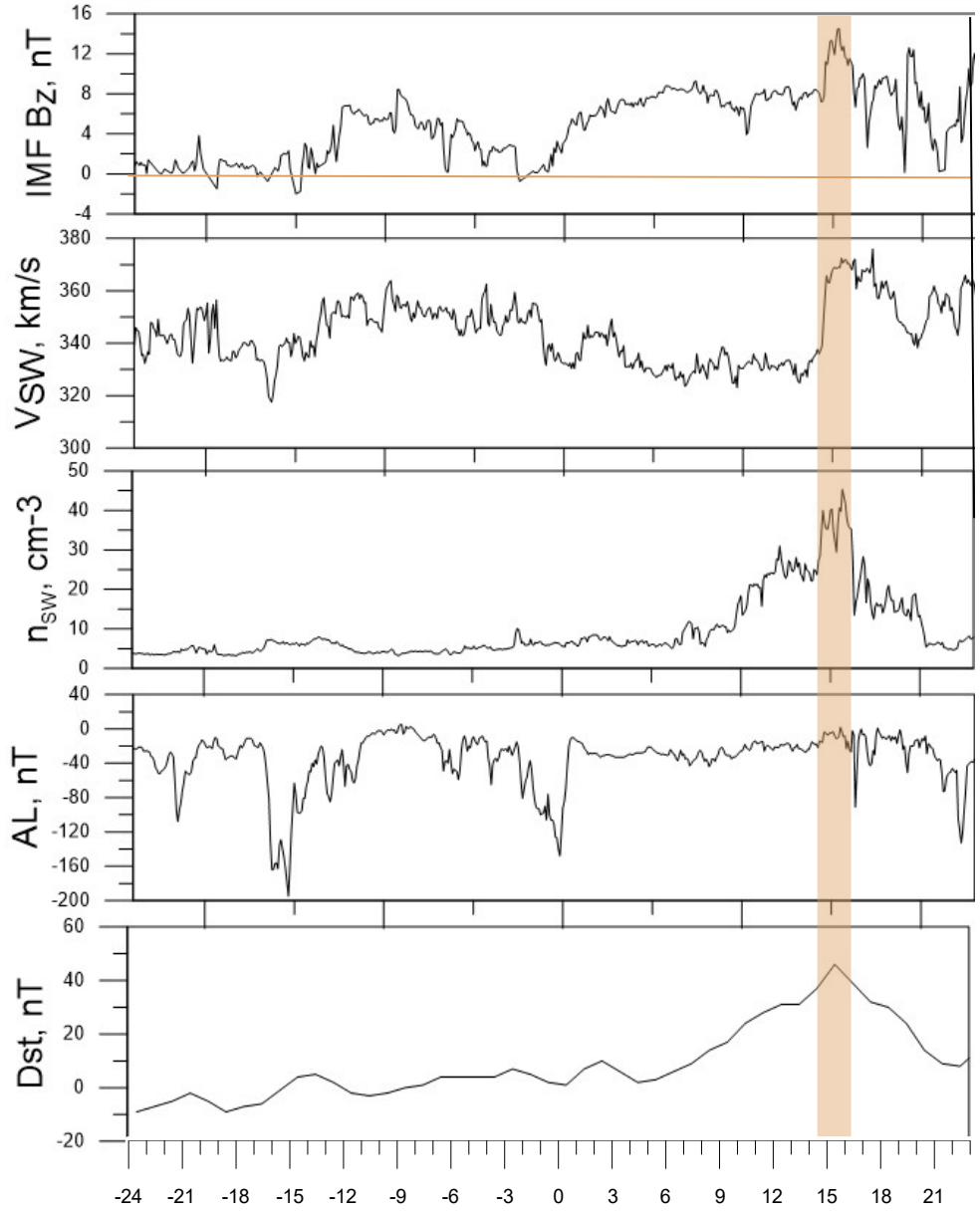


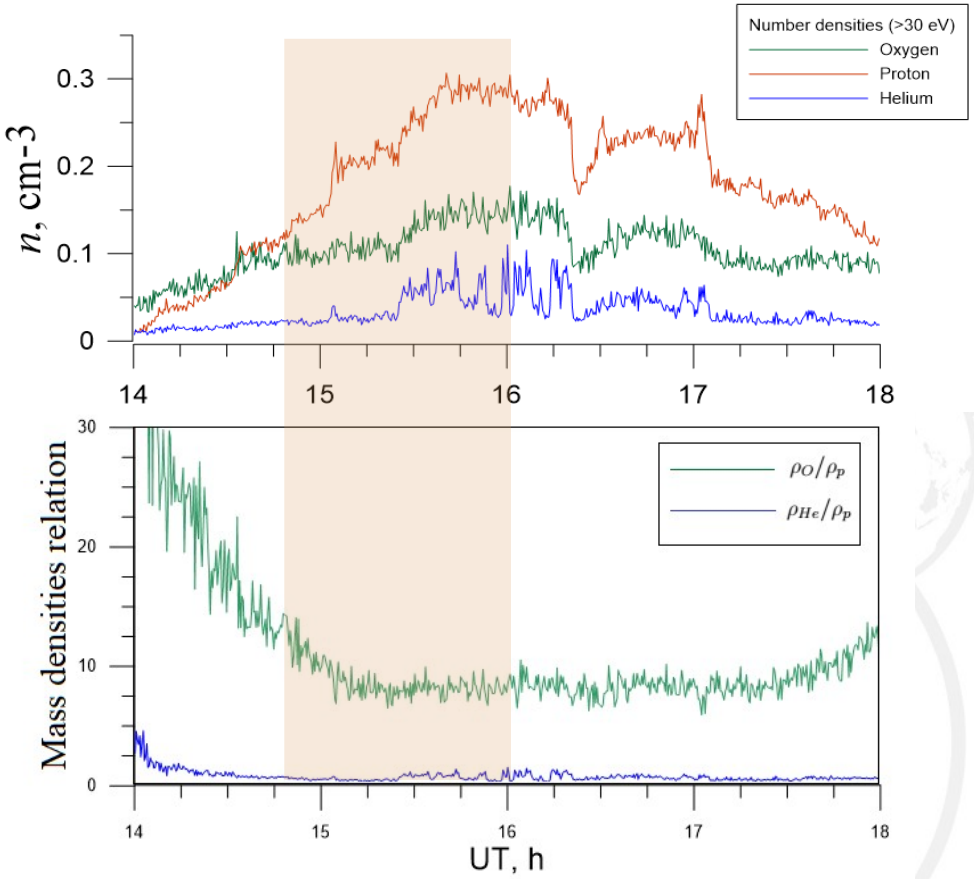


POYNTING VECTOR



PC1 EVENT

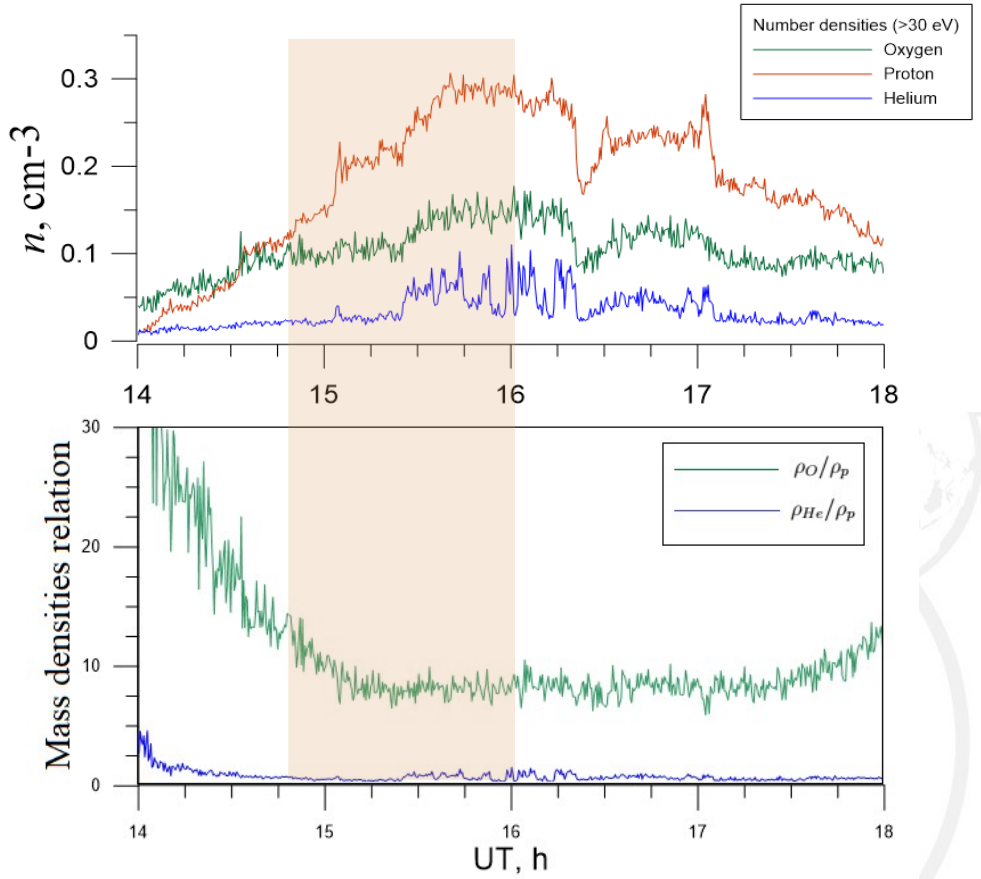

IMF Bz, nT
VSW, km/s
nSW, cm-3
AL, nT
Dst, nT
-24 -21 -18 -15 -12 -9 -6 -3 0 3 6 9 12 15 18 21


Number densities (>30 eV)
Oxygen
Proton
Helium
n, cm-3
Mass densities relation
ρO/ρp
ρHe/ρp
UT, h

PC1 EVENT

$$\omega_n^2 = \left(1 + \frac{\rho_h}{\rho_p}\right)\Omega_{ch}^2 + (2n+1)\frac{\rho_h}{\rho_p}\frac{A_h \Omega_{ch}}{r_{eq}}$$

- Oxygen ions (huge value of) – calculated frequency is too low
- Helium ions (high value of and) – calculated frequency is too low



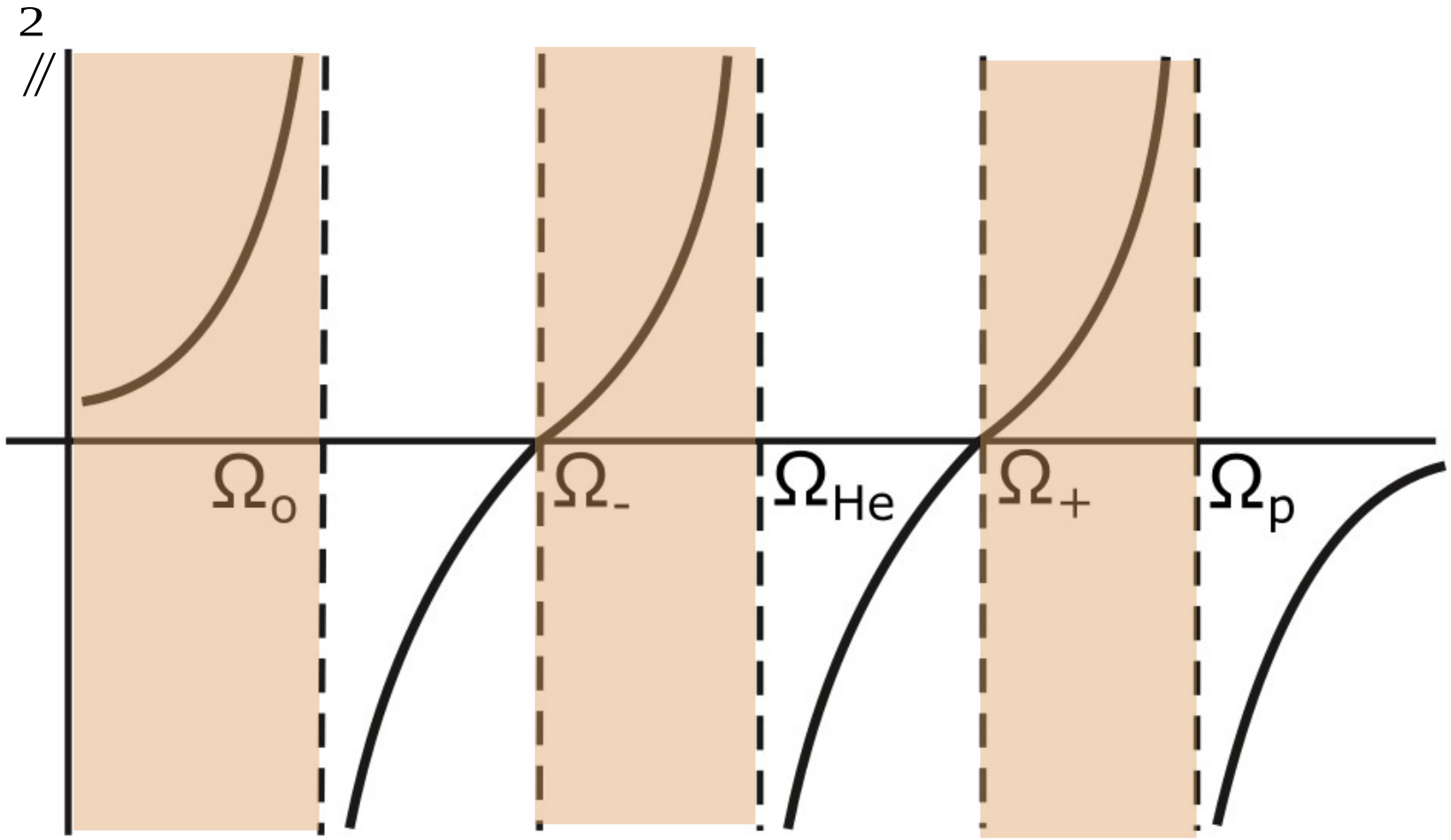
EQUATORIAL LOCALIZATION

+

$$^{2}_{//} = \quad ^{2} + \frac{1}{2} \quad '' \quad ^{2}$$

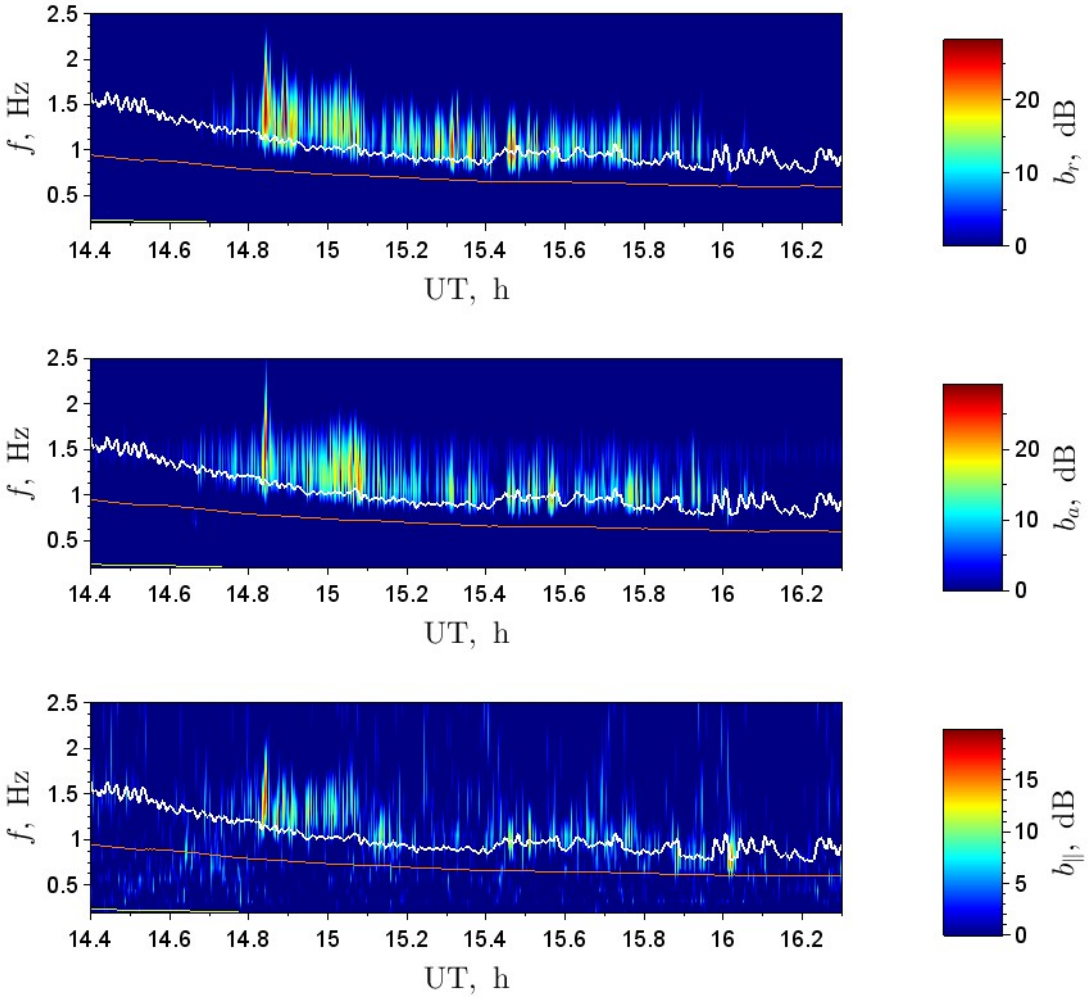
$$^{2} = \left(2 \quad +1\right)\sqrt{-\frac{1}{2} \quad ''}$$

$$^{2}_{//}\left(\Omega_{\pm}\right) = 0$$

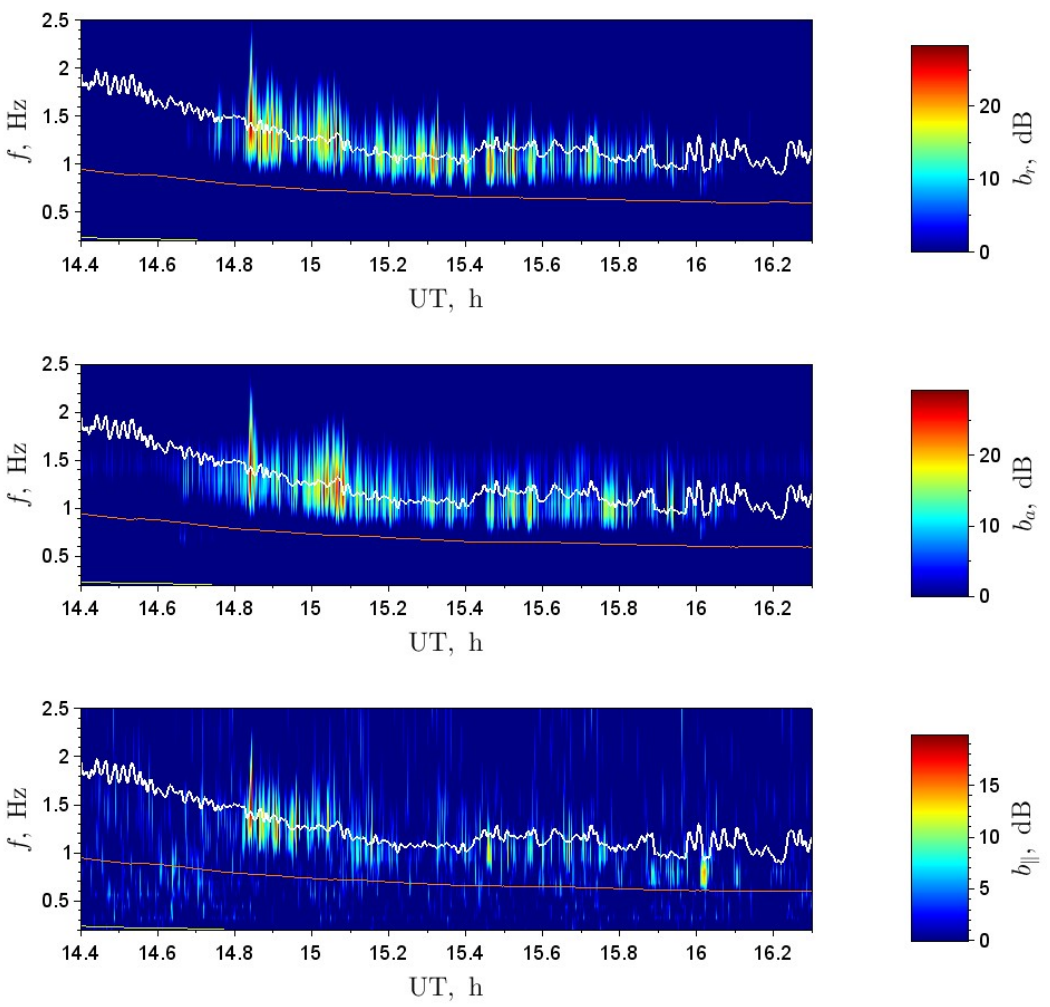


CALCULATED FREQUENCIES

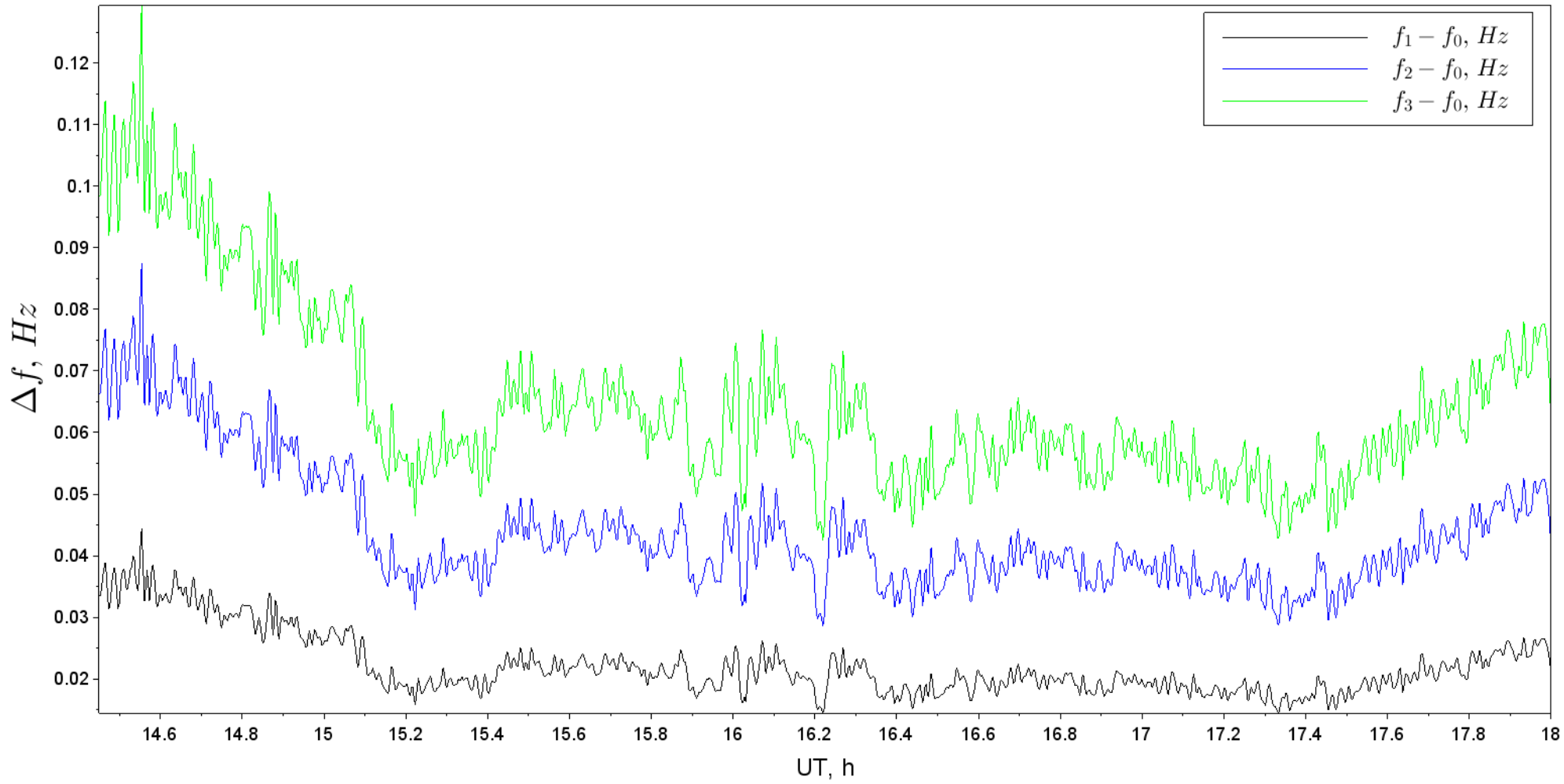
N = 0



N = 10



BEATS


$f_1 - f_0,\ Hz$
$f_2 - f_0,\ Hz$
$f_3 - f_0,\ Hz$
$\Delta f,\ Hz$
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
14.6
14.8
15
15.2
15.4
15.6
15.8
16
16.2
16.4
16.6
16.8
17
17.2
17.4
17.6
17.8
18
UT, h

RESULTS

1. Pc1 pearl event at the frequency just above the helium gyrofrequency was registered by Van Allen Probe A. During the event we observed high densities of oxygen and helium ions.
2. It was shown that theoretical approach have to include the admixture both oxygen and helium ions.
3. We consider this event as evidence of the existence of a near-equatorial resonator for ion-ion hybrid modes in the magnetosphere.
4. The Pc1 wave's frequency corresponds to the calculated frequencies of ion-ion hybrid modes in the near-equatorial resonator.
5. The frequency difference between two close resonator's harmonics is close to the observed Pc1 beat modulations.

THANK YOU!

RESONATOR'S FREQUENCIES

$$^{2} = \Omega^{2} \{ \quad + \quad \}$$

$$= 8 \left[\left(1 + \frac{}{} \right) + \frac{1}{16} \left(1 + \frac{}{} \right) + \sqrt{\left(\left(1 + \frac{}{} \right) + \frac{1}{16} \left(1 + \frac{}{} \right)^{2} - \frac{1}{4} \left(1 + \frac{}{} + \frac{}{} \right) \right)} \right]$$

$$= \frac{3}{\Omega} (2 \quad + 1) \sqrt{\frac{\frac{1}{16} \frac{}{} (1 - \quad)^{2} + \frac{}{} \left(1 - \frac{1}{16} \right)^{2}}{\left[\left(1 + \frac{}{} \right) + \frac{1}{16} \left(1 + \frac{}{} \right) \right]^{2} - \frac{1}{4} \left(1 + \frac{}{} + \frac{}{} \right)}}$$