SCHUMANN RESONANCE OBSERVATIONS

G. SÁTORI

Schumann resonances are the electromagnetic eigenmodes of the Earth-ionosphere cavity maintained by the world thunderstorm activity (Schumann 1952).

The first efforts were already made in sixties to record the variations of the natural electromagnetic energy source in the Schumann resonance (SR) frequency range. P Bencze constructed an equipment for measuring SR and reported on the first results together with A Ádám (Ádám and Bencze 1963).

The experiments were renewed in eighties to realize the continuous measurements of Schumann resonance frequencies and amplitudes. Since May of 1993, the vertical electric field component in SR frequency range between 2 and 25 Hz has regularly been measured in the Nagycenk Observatory (47.6°N, 16.7°E) using a very stable ball-antenna, a preamplifier with high input impedance and low noise, an amplifier and a personal computer with high speed, multi-channel AD-converter. The complex demodulation as a spectral technique has been applied for the quasi-continuous determination of the actual peak-frequencies and the corresponding amplitudes of the first three SR modes (Sátori et al. 1996).

Using convolution filters the phase-variations of the complex wave vector relating to the central period of the filters are determined. By computing the phase changes versus time the frequency (and the amplitude) can also be monitored in time. Using this spectral technique, the frequency can be determined within a given range of frequencies, in the case applied here in the frequency range of the first three Schumann-resonance modes, namely between 7–9 Hz, 13–15 Hz and 19–21 Hz. An alternate sampling and computation process yields a quasi real-time technique.

The horizontal magnetic field components (north-south and east-west) have regularly been measured since January of 1997 using induction coils. The spectral technique is the same as in case of the vertical electric field component.

The electronics of the SR recording system was developed by J Pongrácz and J Horváth, the ball-antenna was constructed by Gy Pálla.

Recording SR-transients started in the frame of US-Hungarian Joint Found (JF.554) in 1998. These events, so called Q-bursts, are excited by individual energetic lighning strokes.

The hourly averages of the peak-frequencies and the amplitudes for the first three modes and SR transients for selected time periods (international campaignes) are available (e-mail: satori@ggki.hu). Figure 1 shows Schumann resonance recording system with the ball-antenna for the measurement of the vertical electric field component, as well as the two induction coils for the horizontal north-south and east-west magnetic field components. Figure 2, as example, exhibits the daily frequency and amplitude variations of the first three modes characteristic for a winter month. Figure 3 depicts a SR-transient.

Some results based on SR observations

The observation of Schumann resonances is important from the point of view of the world thunderstorm activity in the troposphere, as well as the different emissions (red sprite, blue jet, elves) induced by lightning strokes and large scale influences of extraterrestrial origin in the lowest ionosphere.

The semiannual variations of SR amplitudes measured at the Nagycenk Observatory, Central Europe, are the manifestation of the semiannual variation of the surface air temperature in the tropical continental regions (Sátori and Zieger 1996). The latter is due to the semiannual wave of solar insolation with maxima at the equinoxes. The magnitude of the semiannual temperature variation is about 1.5–2.0 °C. The high significance level of the semiannual variation of the SR amplitudes at Nagycenk shows that the quality of this SR data set makes it suitable for detecting temperature variations at the level of some tenths of a degree centigrade. In this way, the observation of the SR amplitudes/intensities have great importance from the point of view of global climatic changes.

Parameters of global thunderstorm activity were deduced from the long term Schumann resonance records at Nagycenk (Nickolaenko et al. 1998).

The ENSO (El Niño Southern Oscillation) phenomenon is among others characterized by sea surface temperature anomaly in the equatorial Pacific which can affect weather patterns around the world. A meridional redistribution of the world thunderstorm activity was deduced from the variations of SR frequencies on the ENSO time scale observed at Nagycenk (Sátori and Zieger 1999).

Lightning properties of the two tropical continental chimneys, the Congo and Amazon basins were compared based on Schumann resonance measurements at Nagycenk, Hungary and Rhode Island, USA and satellite observations (Williams and Sátori 2004).

See CD (program Seenck.exe, menu item SchumannRes).

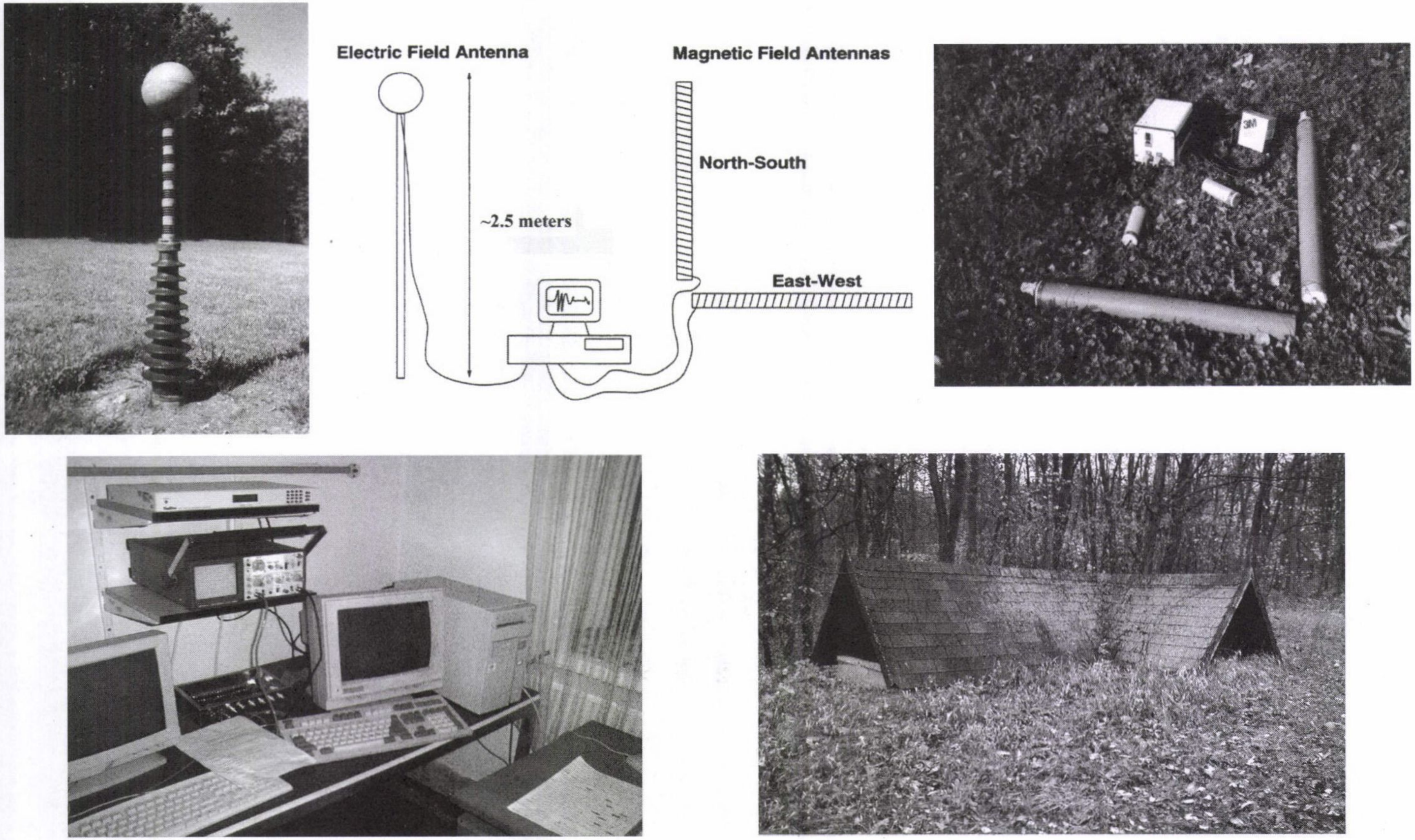

Fig. 1. Schumann resonance recording system: ball-antenna (top left), block diagram of the measurement (top middle), induction coils (top right), data acquisition system (bottom left), hut for the induction coils (bottom right)

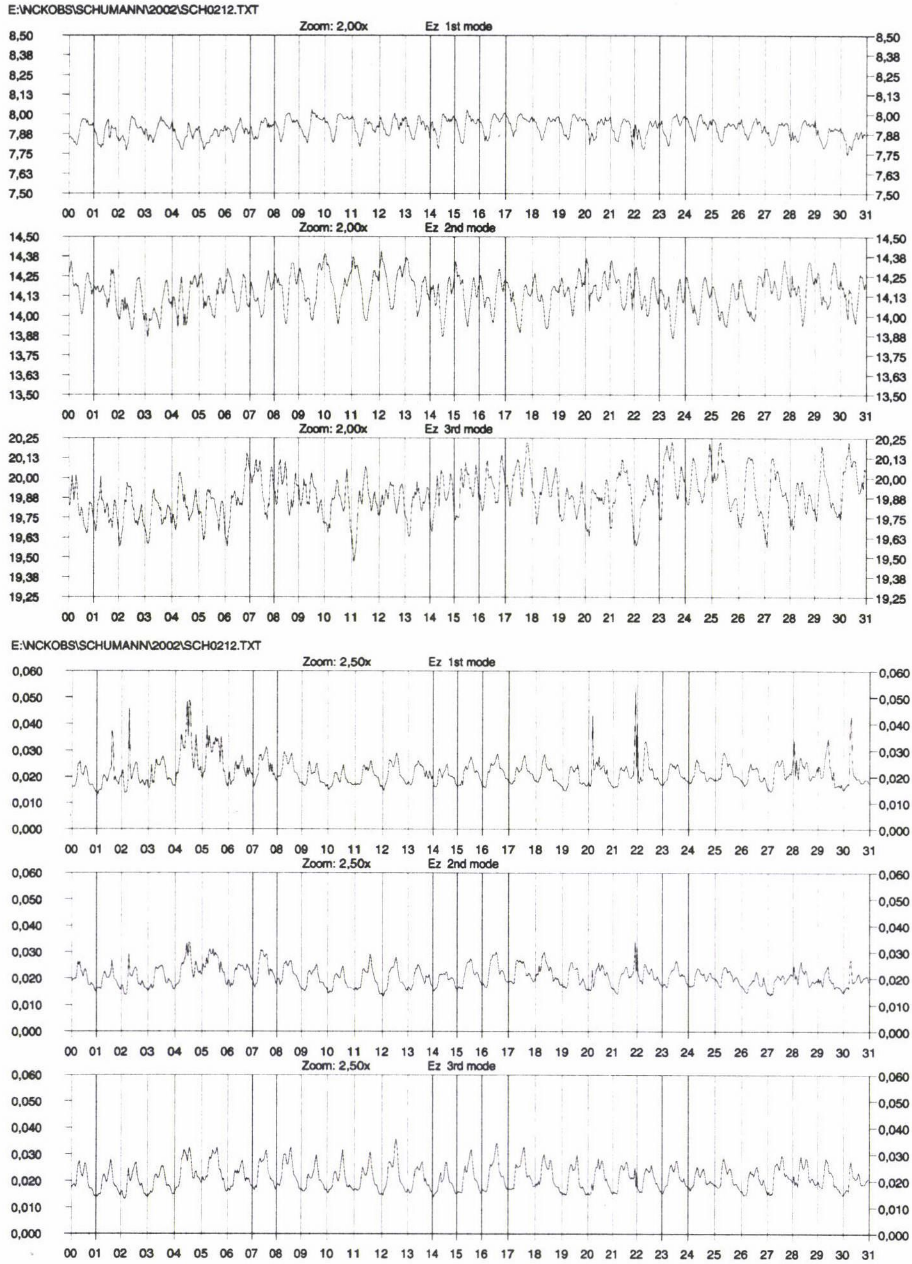

Fig. 2. Hourly means of SR frequencies in Ez (top) and relative amplitudes in V (bottom) measured for the first three modes in the days of December, 2002

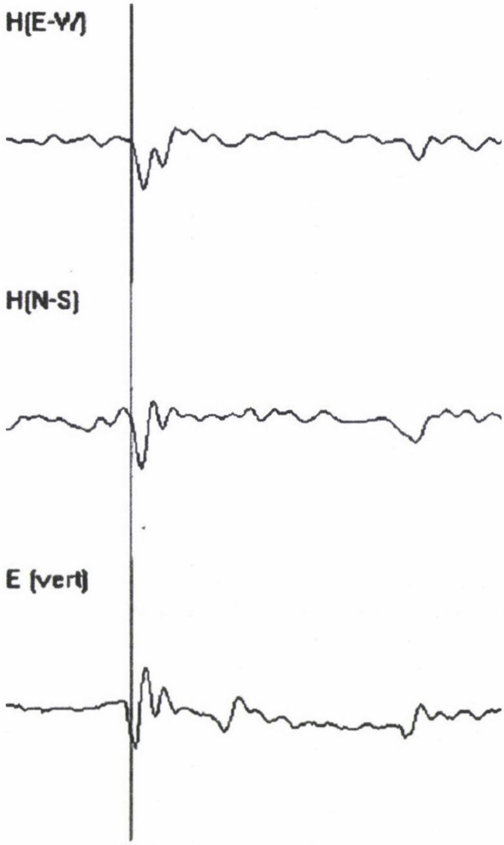

Fig. 3. SR-transient recorded at Nagycenk. Time markers include intervals of 100 ms. The horizontal broken lines indicate the trigger level of ±0.6 V

References

Ádám A, Bencze P 1963: Study of naturalenergy sources in the low frequency band (in Hungarian). *Magyar Geofizika*, 4, 29–35.

Nickolaenko A P, Sátori G, Zieger B, Rabinowicz L M, Kudintseva I G 1998: Parameters of global thunderstorm activity deduced from the long term Schumann resonance records. *J. Atmos. Sol. Terr. Phys.*, 60, No. 3, 387–399.

Sátori G, Zieger B 1996: Spectral characteristics of Schumann resonances observed in Central Europe. *J. Geophys. Res.*, 101, No. D23, 29663–29669.

Sátori G, Zieger B 1999: El Niño related meridional oscillation of global lightning activity. *Geophys. Res. Lett.*, 26, NO 10, 1365–1368.

Sátori G, Szendrői J, Verő J 1996: Monitoring Schumann Resonances – I. Methodology. *J. Atmos. Terr. Phys.*, 58, No. 13, 1475–1481.

Schumann O W 1952: Über die strahlungslosen Eigenschwingungen einer leitenden Kugel, die von einer Duftschicht und einer Ionosphärenhülle umgeben ist. *Z. Naturforsch.*, 7a, 149–154.

Williams E R, Sátori G 2004: Lightning, thermodynamic and hydrological comparison of the two tropical continental chimneys. *J. Atmos. Sol. Terr. Phys.*, 66, 1213–1231.