# Asymmetry in diurnal variation of electron density in D region over Kunming

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## Abstract

Based on MF radar database from August 2008 to July 2009 at Kunming (25.6 °N,103.8 °N), the diurnal of electron density in the D region has been examined. The previous asymmetries of the electron density about local noon in the range of 66km-80km are observed, and at a fixed zenith angle it is shown an asymmetry in the diurnal variation of electron density existing in all the seasons. Particularly the asymmetry is more evident in winter that the rate of the asymmetry increases as increasing height, with a tendency for higher electron densities in the morning below 76km. Seen from the study at solar zenith angle of 48.6°, the diurnal asymmetry is a common feature at all altitudes and for all months with maximum of asymmetry of 3.34 and 3.33 occurring at 66km on October 2008 and at 70km on April 2009, respectively.

## 1. Instruction

The main feature in diurnal variation of electron density of D region is a diurnal asymmetry. So far, many workers have done plentiful researches on the variation feature of electron density based on satellite and ground instruments[1,2,3], in which the common feature observed is diurnal asymmetry in Ne. Hang et al (1970) point detailedly the maximum of electron density asymmetry occurs two hour after noon at Crete(35 °N) observed by partial reflection technology. In autumn at 1964 and 1965 there is no obvious asymmetry at Crete(35oN)[4], though in spring and summer at Ottawa(45 °N) the asymmetry feature exhibits obviously at the same year[1]. At Park Site(52 °N) the diurnal asymmetry in electron density also observed in all seasons at the range from 76km to 82km, that the maximum of asymmetry occurs one hour after noon in spring and summer, one hour before noon in autumn and winter, but in the observation of diurnal asymmetry at Urbana(40°N) asymmetries in the diurnal behavior were also observed with a tendency for higher electron densities in the morning[5]. Though a number of reasons could be used to explain the observed asymmetry, no satisfactory explanations to the occurrence of asymmetry in electron density have been given so far.

In this paper, we give the observation feature of diurnal asymmetry based on the D region electron density data at Kunming station from August 2008 to July 2009 observed by MF radar. So far, we have done lots of significant researches [6-10].

## 2. MF radar and data

The MF radar, located at Kunming Radio observatory, uses the different absorption experiment (DAE) technique[11] to observe the electron density in D region. The MF radar transmits circularly polarized radio wave at a frequency of 2.138MHZ with the O-mode during the day and E-mode at night. The range observed is from 50-100km with height resolution of 2 km and time resolution of 3min., which was detailed in other work[12]. The electron density data in D region of twelve months from August 2008 to July 2009 are used in our asymmetry analysis.

## 3. Results

Figure 1 displays the variation of electron density asymmetry with respect to solar zenith angle from 66km to 80km for the year of August 2008 to July 2009. Black real line represents the electron density before noon, and black dashed line represents the electron density after noon. We can see from Fig 1 that the asymmetry exists in almost all the months at every altitude. For instance, at 66km the electron density at larger solar zenith angle enhances suddenly in spring and winter and August, but no obvious variation of asymmetry in other seasons. At 80km there has evident asymmetry phenomenon in spring and winter and August, but variation is complex in summer and autumn. A common feature at other altitudes is that asymmetry behaves evidently in spring and autumn. It is worth noting that for all seasons the behavior of asymmetry changes according to the time of the day and altitude .Asymmetry usually means higher electron densities were observed after noon at the same solar zenith angle. It is need to note that Fig 1 shows higher electron densities observed before noon for some cases, though most electron densities observed before noon at Buckland Park [13]. At lower altitudes in some months there has an additional ionization, which may be the cause for higher electron densities observed before noon. So care must be considered in explaining the reasons for this asymmetry behavior at different altitude and month, because the main ionization sources or mechanisms for producing free electrons at different altitude or time should be different.

Table 1 the rate of electron densities at $\chi = 48.6°$

| Height | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66km | Inf | 1.08 | 3.34 | 2.05 | 0.99 | 0.86 | 2.72 | Inf | Inf | 1.57 | 0 | 0 |
| 68km | Inf | 1.12 | 1.96 | 1.18 | 0.87 | 1.39 | 0.71 | 2.43 | 0.82 | 1.97 | 2.95 | Inf |
| 70km | 2.97 | 1.24 | 1.34 | 1.14 | 1.21 | 1.27 | 1.33 | 1.68 | 3.33 | 1.97 | 1.38 | 1.43 |
| 72km | 1.59 | 1.08 | 1.36 | 0.87 | 0.92 | 1.25 | 1.66 | 1.86 | 2.28 | 1.66 | 1.47 | 2.43 |
| 74km | 2.17 | 0.76 | 1.04 | 1.55 | 0.9 | 1.15 | 1.64 | 1.40 | 2.62 | 1.88 | 1.37 | 1.27 |
| 76km | 1.93 | 1.26 | 1.54 | 1.10 | 0.77 | 1.43 | 1.51 | 1.18 | 1.39 | 1.72 | 1.32 | 1.88 |
| 78km | 1.97 | 2.47 | 1.75 | 1.99 | 0.53 | 1.35 | 1.36 | 1.83 | 1.10 | 1.48 | 1.01 | 1.64 |
| 80km | 1.44 | 0 | 0.92 | 2.10 | 0.71 | 1.48 | 1.96 | 2.24 | 0.78 | 1.60 | 2.47 | 0.89 |

Table 1 gives the rate of electron densities at zenith angle of 48.6$^{o}$. For seasonal comparison a zenith angle of 48.6$^{o}$ exists in every month of the year. Similarly the asymmetry phenomenon almost exists all the months for all altitudes seen from Table 1. The maximum of asymmetry of 3.34 occurs at 66km on October 2008, then the second maximum of asymmetry of 3.33 occurs at 70km on April 2009, but no effective values are observed in the morning at 66km and 68km on August, 66km on March and April, 68km on July, in addition no effective values afternoon at 80km on September and 66km on June and July. Compared with all months, the rate variation has a larger fluctuation in April, but the rate values are mainly less than 1 in December for all altitudes except for 1.21 at 70km, that there has higher electron density in morning. The result is very good in May as higher electron density occurs afternoon for all altitudes. Seen from Table 1, the results at 76km and 78km are more ideal because their values are larger than 1.

## 4. Conclusion

Possible mechanisms which may be the cause of this asymmetry are investigated, but the simplest explanation is often given with continuity equation[13]. The electron production rate and the electron loss coefficient are two main parameters Correlating to these parameters, Forbes(1981)investigated the D-region asymmetries via a change of the electron loss rate due to diurnal asymmetric neutral temperatures[14]. Lastovicka(2001) analyzed the diurnal asymmetry of NO using multi frequency radio wave absorption

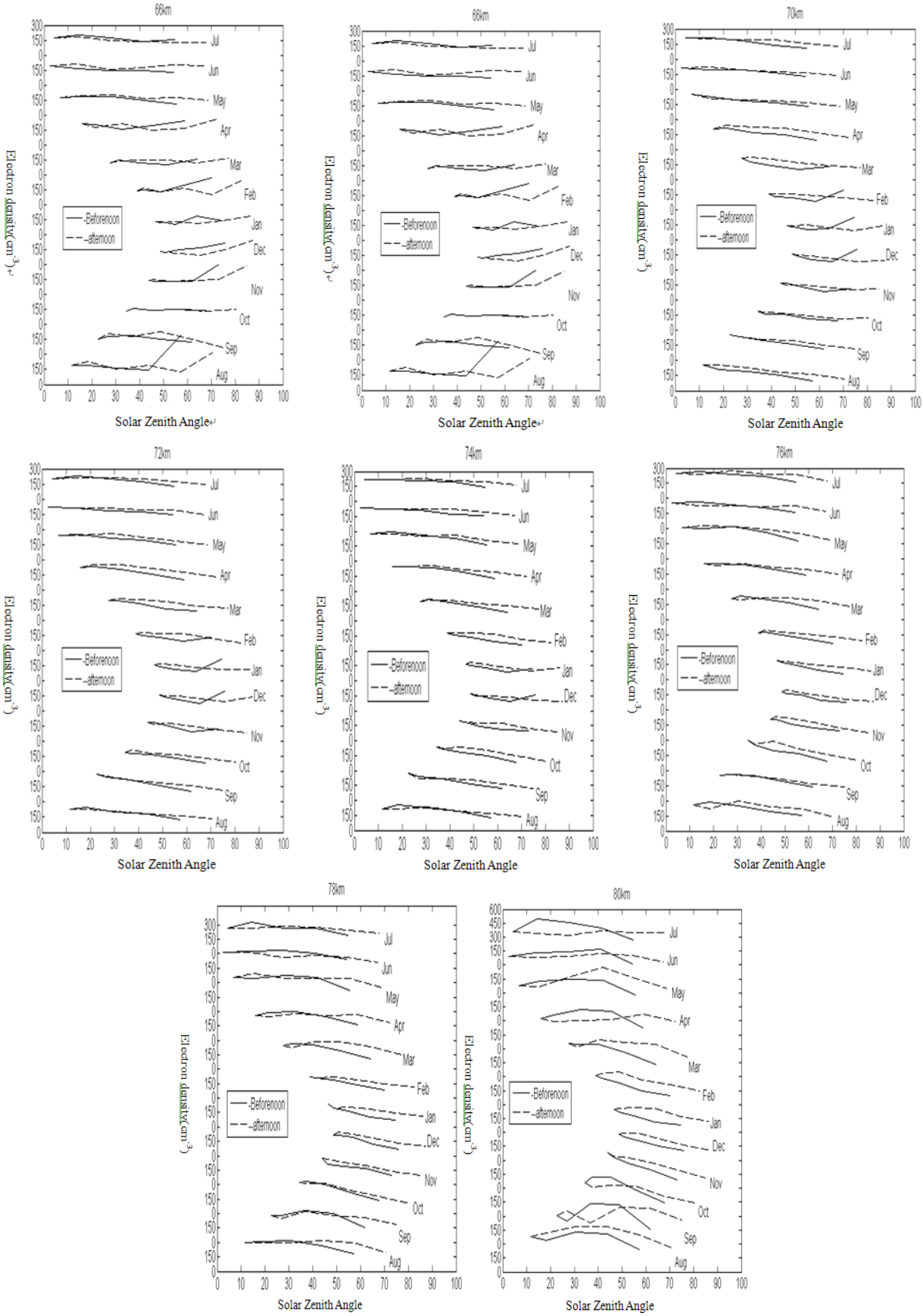


Fig 1 Electron density with respect to solar zenith angle from 66km to 80km for the year of August 2008 to July 2009. Black real line represents the electron density before noon, and black dashed line represents the electron density after noon.

measurements[15].

In this paper, the variation of diurnal asymmetry of D region electron density is given using data observed by MF radar located at Kunming with DAE technique. The results show that the asymmetry phenomenon almost exists all the months for all altitudes, but change differently with different altitude. Seen from the analysis at solar zenith angle of 48.6$^{o}$, the diurnal asymmetry is a common feature at all altitudes and for all months with maximum of asymmetry of 3.34 and 3.33 occurring at 66km on October 2008 and at 70km on April 2009, respectively. Discussion concerning on mechanisms producing this phenomenon will be done in our future work.

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