

USING REISSNER-NORDSTROM SOLUTION FOR MODELING  
EPILEPTIC SEIZURES

NORAINI BINTI ISMAIL

A Thesis submitted in fulfilment of the  
requirements for the award of the degree of  
Doctor of Philosophy (Mathematics)

Faculty of Science  
Universiti Teknologi Malaysia

MAY 2013

*To all muslim ummah... ..*

## ACKNOWLEDGEMENT

All praise is to Allah swt, the truth and the only God deserved of All Praise and Submissions. Peace and blessing to the blessed and chosen prophet, Muhammad saw, who is the messenger and the teacher of the truth.

A lot of work, time, effort and energy were place upon this research. Nonetheless, the journey going through the process of becoming learned and experienced individual, with more courage and perseverance was a very tough one. It was the journey of life itself, which changes me to become a better person mentally, physically and spiritually, with a very clear goal in this life and the next.

Indeed, a lot of people deserve my appreciation. I am grateful to my husband for words of encouragement and support and for solving all technical problems I faced with computers promptly. To all my brothers and sisters for their words of advice, their supportive actions they gave, the hope they have and the pray they made for me. May Allah bless them all. My very special thanks and appreciation to my supervisor, Prof Dr Tahir Ahmad, for unchallenged patient, for unexhausted support and for always believe in me. May Allah bless you with best rewards for only Allah alone could measure.

Last but not least, special thanks to Universiti Teknologi Malaysia for funding this entire study especially the last two previous semesters where the tuition fees were waived. My sincere appreciation is to all my colleagues and others who have help and assist me in any ways either direct and indirectly. Thank you all.

Noraini Ismail

## ABSTRACT

Modeling of the brainstorm of epileptic seizure is to find and follow paths of clusters of charges carried by ions from epileptic foci to the scalp area of the brain. This will also estimate the location of the epileptic foci or onset of the seizures. The foci may be located in a small volume of brain tissue due to unusually large accumulation of ionic charges. As a seizure begins, the electrostatic repulsive force among these ions throws the ions outward in all directions along 100 billions neurons inside the brain. These charges of electric pulses arrive finally at the scalps, and are recorded as electroencephalography (EEG) voltage signals. Modeling this event poses challenges since seizures might start at other locations at the same instant. Hence, the mixture of paths from different foci is unavoidable which resulted in a very chaotic trace of EEG signals. Sporadic ionic burst of the epileptic brainstorm is very similar to the event of the Big Bang. The tremendous explosion originated from a point of singularity, threw all matters and space outwards, and started the expansion of the universe. The journey of the matters along with this expansion provides a good model for the journey of the charges to the scalp during brainstorm epileptic seizure. General relativity states that the fundamental force of gravitation can be described as a curved space-time caused by the presence of matter and energy. Thus, matters move along this curve space-time, during the expansion of the universe. Likewise, electrostatic field of charges curved space provides path for the charges' journey during epilepsy attack. Exact solution to the Einstein Field equation of fluid which describes the expansion of the universe may also give exact solution to Einstein field equation of electromagnetic field which describes the path of the ions during epilepsy attack. The electrovacuum solution of Reissner-Nordström metric of a charged, non-rotating black hole is suited to the variables of the model. Results obtained were then compared to another result that was obtained by using pixel image method of flat EEG. The percentage agreement is around 56.3% and was determined by the number of pixel dots that actually resides in the spherical domains of the charges' paths. Significantly and interestingly enough, 33% of the lengths of the paths are less than 4 mm while 67% are much deeper inside the brain. This value totally agrees with the percentage of folded cortex deep inside the brain and far from the scalp.

## ABSTRAK

Memodelkan ribut otak semasa serangan sawan dalam kajian ini bertujuan untuk mengesan dan mengikuti perjalanan kelompok-kelompok cas yang dibawa oleh ion-ion dari lokasi bermulanya serangan hingga ke kawasan tengkorak kepala. Ini juga dapat menganggarkan lokasi titik bermulanya punca sawan bagi ribut otak tersebut. Titik ini dapat dikesan pada satu kawasan kecil tisu otak di mana terdapat pengumpulan cas-cas yang lebih banyak dari biasa. Apabila serangan bermula, daya tolakan elektrostatik di antara cas-cas ini menyebabkan ion-ion tertolak keluar ke semua arah dengan melalui lebih dari 100 billion neuron-neuron dalam otak. Cas-cas ini kemudiannya tiba di tengkorak kepala dan di kesan sebagai isyarat voltan EEG. Membangunkan model pegerakkan cas ion-ion ini merupakan cabaran yang besar. Serangan sawan boleh berlaku di beberapa lokasi yang lain pada ketika yang sama dan oleh itu, percampuran jejak cas-cas ini tidak dapat dielakkan lalu menghasilkan isyarat EEG yang kelam kabut. Letupan spora cas-cas ini adalah serupa dengan gerakan jisim alam yang meledak kuat ketika berlakunya fenomena Big Bang. Letupan hebat ini bermula dari satu titik singular yang mencampakkankan jisim ke semua arah, lalu memulakan pengembangan alam semesta. Perjalanan jisim bersama pengembangan alamraya menyediakan satu model yang sesuai untuk perjalanan cas-cas ke kawasan tengkorak semasa serangan rebut sawan. Relativiti umum, menyatakan bahawa daya gravity adalah sama dengan lengkungan ruang masa yang disebabkan oleh kehadiran jirim dan tenaga. Oleh itu, jisim bergerak menyusuri lengkungan ruang masa ini. Keadaan ini adalah serupa dengan medan elektrostatik kelompok cas-cas yang melengkungkan ruang masa dan memberikan jejak bagi perjalanan cas-cas semasa serangan sawan. Penyelesaian tepat kepada persamaan medan Einstein bagi bendalir yang juga menerangkan pengembangan alamraya boleh memberikan penyelesaian yang tepat juga bagi medan elektromagnetik kelompok cas-cas. Penyelesaian elektrovakum metrik Reissner-Nordström bagi lubang hitam yang tidak berputar dan tak bercas kemudiannya di suaikan dengan parameter-parameter model. Keputusan yang terhasil dibandingkan dengan keputusan dari kaedah penghasilan imej piksel EEG Datar. Purata peratusan kesamaan adalah 56.3%, dimana angka ini ditentukan dengan menjumlahkan titik-titik piksel yang berada didalam domain sfera yang jejaringnya adalah jejak perjalanan kelompok cas-cas tersebut. Yang paling ketara, 33% dari panjang jejak-jejak adalah kurang dari 4mm dalam, sementara 67% yang selebihnya adalah lebih dalam. Nilai ini adalah tepat dengan peratus luas kortex yang terlipat dan jauh dari tengkorak kepala.