GEOSPATIAL ANALYSIS OF ROADSIDE FRICTIONAL POINTS IN KADUNA METROPOLIS, NIGERIA

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ABSTRACT

The door to door capacity of road transportation makes it the largest means for conveying goods and commuters. Available statistics showed that the total number of vehicular plate numbers produced in Kaduna State were 16,658 and 24,728 in 2013 and 2014 respectively, which is a high increase. The increase ownership of vehicles among other reasons leads to deterioration in capacity and inefficient performance of traffic systems. Expansion of road infrastructure is not always the solution although it will not absolutely be ruled out as the demand may be expected to continue to grow, the immediate, most relevant and acceptable strategy to mitigate capacity problems and increase efficiency of the road network is through traffic management applications. This study identified and analysed roadside frictional points in Kaduna metropolis with a view to predicting and characterizing the impact of roadside friction on vehicular speed and curtailing the poor performance of traffic systems. Stationary and mobile observation methods were applied to acquire data in addition to ulysse speedometer recorder and five factors of Pedestrians walk, Pedestrians cross, Non-Motorized Vehicle, Hawking and On-street parking were taken using Hierarchical Analytical Model as the main causes for roadside friction in the study area. Five roads were sampled for the identification, they were: Ahmadu Bello Way, Ali Akilu Road, Constitution Road, Independence Way and Nnamdi Azikwe Road. The results revealed high presence of the causes of roadside friction in some roads and lean on others. The result also revealed the reduction of about 11.67% of speed on constitution road, the lowest and 15.83% on Ali Akilu road and Ahmadu Bello road, the highest on operating speed. It was recommended among other recommendations that Kaduna State Traffic and Law Enforcement Agency (KADSTLEA) should rise up to enforce laws with regards to unlawful on-street parking, commercialization of roadside by hawkers and beggers in the study area.

Key words: Friction, Kaduna metropolis, Roadside, Traffic, Transportation

INTRODUCTION

Transportation gives all economic activities direction all over the world. Transportation can be carried out on railways, waterways, airways and roads. Among these transportation facilities, roads take the biggest proportion because of its affordability and its door to door capacity. This is one of the reasons most transportation planning and researches pay attention on road transportation. In short, road transportation is the engine of the economic activities of all communities (Chiguma, 2007).

Increased travel demand has resulted in rapid growth in the number of motor vehicles in the cities. For example, Abam and Unachukwu (2009) reported that Federal Road Safety Commission of Nigeria (FRSC) had registered about six million (6,000,000) vehicles between 1999 and 2004 and that 70% of these were cars while 30% were buses and trucks. Also, available statistics showed that the total number of vehicular plate numbers produced in Kaduna State were 16,658 and 24,728 in 2013 and 2014 respectively (National Bureau of Statistics, 2015).

Urban transportation calls for efficient utilization of road space in cities in the most effective way while planning for any expansion or enhancement. At network level, functional performance of hierarchal roads according to their expected supply of mobility and accessibility is essential for desired quality of service to the road users. Arterial roads in metropolitan cities are designed to provide mobility to high volume of traffic between major traffic generators and attractors. Observations on such roads in most developing cities like Kaduna show lack of control of road side activities and traffic operation is mixed with slow moving vehicle/non-motorized vehicles along with the fast moving vehicles. Effect of these two phenomenon on traffic flow drastically reduces the carrying capacity of roadway (Chetan and Joshi, 2014).

However, the familiar tools that are applied to increase capacity and improve efficiency include and not limited to: prioritization of road users (i.e. introduction of truck lanes, bicycle and pedestrian routes, peak lanes, etc.), road hierachisation (i.e. classification of road function), road markings and signs, enforcement devices (i.e. camera, police patrol, etc.), regulation of parking space, congestion charges, fuel prices, traffic restraints (i.e. limiting entry to city centre, pedestrization of city centre, etc.), improvement of public transportation, etc. These tools are relatively cost-effective and technologically affordable and are applicable both in developing and developed countries. Despite their seeming affordability, yet they are not effectively implemented in most developing countries including Kaduna metropolis (Chiguma, 2007).

One of the many causes of deterioration of capacity and poor performance of roads is roadside friction. Side Friction factors are defined as all those actions related to the activities taking place by the side of the road and sometimes within the travelled way (like bus stops, unauthorized parking), which interfere with the traffic flow on the travelled way. They include but not limited to pedestrians, bicycles, non-motorized vehicles, parked and stopping vehicles, bus stops, petrol pumps on the road sides, etc. These factors are normally very frequent in densely populated areas in the developing economies (Amudapuram, 2014).

A number of studies that have to do with Road Infrastructure, Traffic Congestion, Road Transport Accident and Road Characteristics have been conducted by different scholars to address these problems similar to roadside friction as obtained in Kaduna metropolis elsewhere.

For instance, Chandra (2000) studied the effect of shoulder condition on the speed of different types of vehicles and their placement on the road during passing and overtaking manoeuvres and how it affects the capacity values in India using models and recent findings from other researchers. The capacity of road during overtaking was worked out by the combined effort of Chandra and Kumar (2003) for two lanes National Highways and the result found was 3140 PCU hr^{-1}.

Yuan, Jiang, and Wu (2007) studied traffic characteristics on a two lane road consisting of a mixture of buses and cars in China. They developed a model in which buses can only drive on the right lane and investigated dynamic behaviour of the traffic at different densities. Rudjanakanoknad (2009) used oblique cumulative plots to study the effect of various factors such as illegal parking, interrupted U-turns from the opposing direction and interrupted crossover right turns from an access road on urban street bottleneck capacity in the city of Bangkok of Thailand.

In addition, George (2014) had proposed analysis of roadside friction on a major arterial in thickly populated urban cities viz. Mumbai, Bengaluru, and Thiruvananthapuram all in India. Side frictional factor was limited to pedestrian movement along the roadside, the bus stopped at bus stops and on street road parking. Multiple linear regression analysis was selected to represent their relationship. Reduction in speed was studied for all individual factors and also for combined effect. They concluded that side friction has a significant effect on speed and need to include side friction in all traffic related studies for proper management.

Similarly in Nigeria, Bashiru and Waziri (2008) studied the problems of intra-urban traffic in Lagos, Nigeria and they found that 57% of commuters and motorists spend between 30 to 60 additional minutes on the road due to traffic congestion, with the worst high traffic incidence occurring on Mondays. Aderamo and Atomode (2011) also examined the problem of traffic congestion at road intersections in Ilorin. The study found that traffic wardens and on street parking problems are the greatest causes of traffic congestion/delays at road intersections in Ilorin.

The previous studies reviewed were carried out in other parts of the world and the country and none focused in Kaduna metropolis, despite the increasing congestion and traffic irregularities in the area. It is against this backdrop that this research is conceived to identify the roadside frictional points and factors in the area with a view to predicting the impact of side friction and proffering solution.

THE STUDY AREA

Kaduna is the capital city of Kaduna State, Nigeria. It is a part of the central high plain of the northern Nigeria and is about 570 metres above the sea level. Kaduna is located at Latitudes 10°24'-10°38'N and Longitudes 7°23'- 7°29' E. The British colonial officials led by Lord Fredrick Lugard selected Kaduna as the regional headquarters of Northern Nigeria in 1912. Kaduna derived its name from a Hausa word "Kadduna" meaning crocodiles then found in River Kaduna (Ajibade and Okwori, 2009). Kaduna metropolis is a trade centre and a major transportation hub for the surrounding agricultural areas with its rail and road junctions. It is served with a fast and a comfortable rail transport system from the Federal Capital Territory with Intercity transport in commercial buses and tricycles (Field survey, 2016). The study area is parts

of four Local Government Areas of Igabi Local Government Area and Chikun Local Government Area, Kaduna North and South Local Government Areas (See Figure 1).

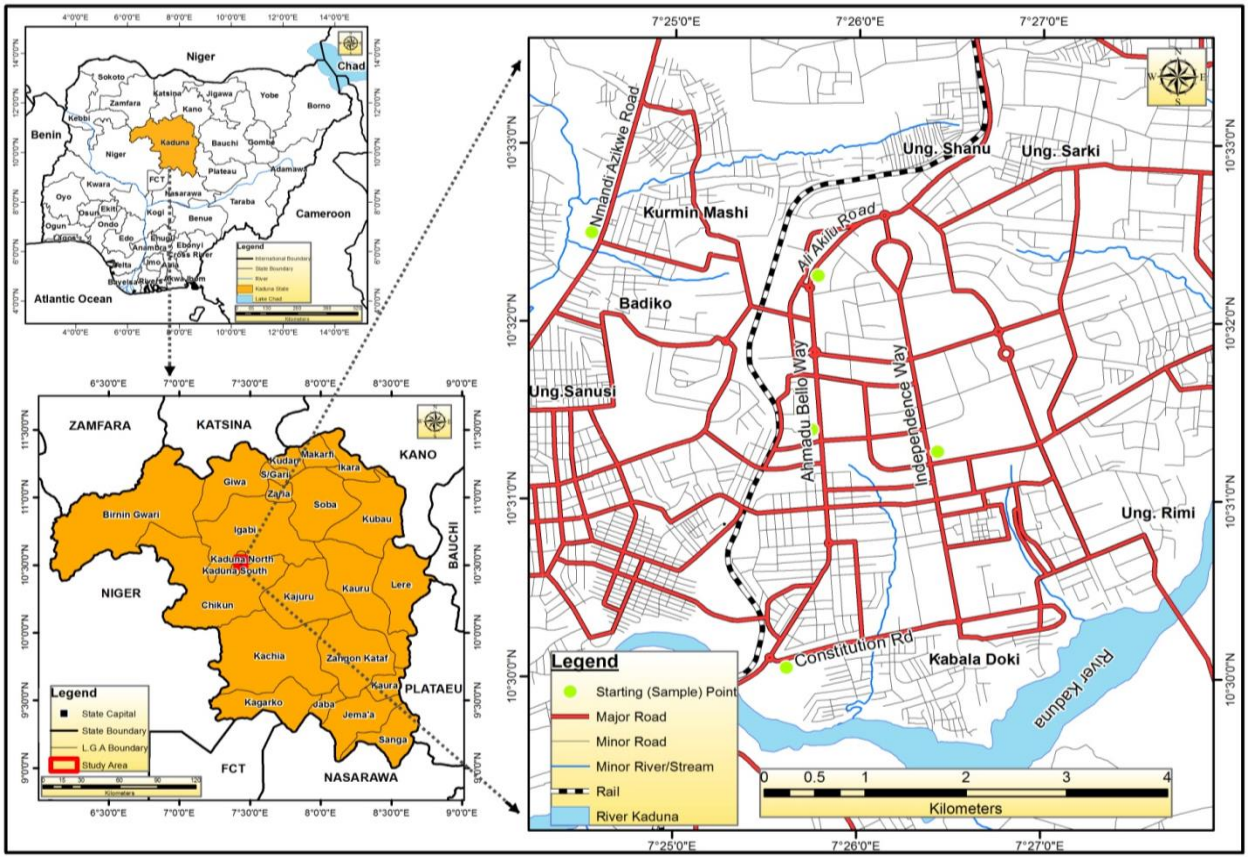

Figure 1: Kaduna Metropolis and the Selected Sampling Points
Source: Modified from the Street Map of Kaduna Metropolis

MATERIALS AND METHODS

A reconnaissance survey and physical field observation of the study area was carried out to familiarize the researcher with the study area. This has assisted the researcher immensely in planning for the collection of data during field work. High congested places were not chosen because they will not reveal the required results. High congested places would delay flow of traffic excessively and what is needed in the research is vehicular speed records and highly congested places often stop vehicular movement. So places like Kano Road, Kasuwan bacci, roundabouts and junctions were excluded and lean places were also excluded, for there will be no road friction in them. Since there are no standard approaches to measurement of side friction, a great deal of experimentation was carried out as described below:

Stationary Observation

Stationary observation was made using surveyors in the field. The observation was continuous and covered all the study sections. One person stood at the point of origin and the second person at end with the length covering a distance of 200 metres.

Mobile Observation

A surveyor moves around the area designated for the posting speed and observing how the movement of the probe vehicles takes off and stops. Car speed was recorded for each side of the four-lane two-way roads. A posting speed of 65 $kmhr^{-1}$ was adapted throughout the study sections to come up with predicted effect or impact of roadside friction on flow and speed in line with the Nigerian standard of 50 $kmhr^{-1}$ in built up areas and 80 $kmhr^{-1}$ in highway (Nigerian Highway Code, 2017). 50+80/2=65 $kmhr^{-1}$. The speed of travel on the study corridors were collected by probe vehicle, performance box and ulysse speedometer recorder (android phone application software). Multiple runs data was collected on each corridor by covering the morning, forenoon, afternoon and evening. The average speed of vehicles on each corridor is presented in Table 2. Four days were used in acquiring the data (24-10-2016 to 28-10-2016). In getting the posting speed, the ulysse speedometer was mounted on a car dashboard for easy capturing and the car speed was recorded for each side of the four lane- two-way road to give the average speed.

Justification of the Method of Analysis

Stationary observers were used because the study segments were short enough (approximately 200m) to be observed by a stationery observer. Side friction was recorded simultaneously, separately for each side of the four-lane two-way roads with a surveyor taking manual recordings. The items of side friction recorded by the surveyor were the following:

i. Parked/stopping vehicles (by type) for a specified time interval (preferably five minutes intervals), (Parked vehicle means the vehicle is not moving for much longer time, while stopped vehicle means the vehicle is temporarily not moving probably for just few seconds loading or unloading)

ii. Pedestrians crossing the road or walking along during the same time intervals

iii. Non-motorized vehicles along the shoulders or in the travelled way (these essentially included slow moving vehicles such as push-carts and bicycles along the shoulders).

The section ends were clearly marked with tape across the roadway by surveyors. It was planned that the survey period covered all levels of traffic flow, from low flow to medium and high flow, in order to define the speed-flow curve as completely as possible. A surveyor recording side friction events was stationed in the middle of the studied segment in order to have the full view of this segment. If two surveyors were required, they positioned themselves relatively opposite to each other as explained above.

Several factors were identified to affect free flow and cause roadside friction. They are as follows:

Pedestrians walk and Pedestrian cross, Non-Motorized Vehicle (NMV), On-street parking (OP), Hawking, Driver's age and experience and Herdsmen and cattle crossing along the road.

Five factors; Pedestrian walk and cross (PW&C), Non-Motorized Vehicle (NMV), On-street Parking (OP) and hawking were identified during reconnaissance survey as the major traffic factors that cause roadside friction in the study area. Decision on the five factors chosen was

made using Analytical Hierarchical Process (AHP). AHP is a useful systematic decision-making tool which decomposes a complex multi-factor problem into a hierarchical structure and each hierarchy is composed of specific elements (Asakereh, *et al*, 2014).

RESULTS AND DISCUSSION

The five roads of Ali Akilu Road (AA Road), Ahmadu Bello Way (AB Way), Constitution Road (Const Rd), Independence Way (Indp Way) and Nnamdi Azikwe Road (NA Road) revealed the following frictional factors identified and characterized as presented in Table 1. Where less than 10 PW, H, NMV and OP were recorded within two minutes in a location is termed Low while 10 or more PW, H, NMV and OP present in a location within two minutes are termed heavy.

Table 1: Frictional Points and Factors Identified and Characterized in Kaduna Metropolis

Location	P. Walk	P. Cross	O. Park	NMV	Hawking
AA Road	Low	Low	Heavy	Low	Low
AB Way	Low	Low	Heavy	Low	Low
Const Rd	Low	Low	Low	Heavy	Low
Indp Way	Low	Low	Low	Low	Low
NA Road	Low	Low	Heavy	Low	Low

Source: Field Survey, 2016

AA Road, AB Way, Const Rd and Indp Way recorded three low readings and one heavy at different times. The roads are the heart of the city and a lot of attention is given to them by the Kaduna State Traffic Environmental Law Enforcement Agency (KADSTLEA) this help to regulate the frictional factors to the minimum. At AA Road, AB Way and NA Way, only OP was heavy and is as a result of taking and discharging passengers by commercial vehicles like buses, taxis and tricyle (Keke Napep) which was high. At Const Rd, NMV (Keke Napep) presence was heavy and impedes the traffic movement. Only independence way recorded high speed because the presences of four frictional factors were very low.

Observed speed against predicted speed in Kaduna Metropolis at the different road segments is presented in Table 2. The observed speed is the predicted speed which can be used as model. A short fall of 14.50 $kmhr^{-1}$ (22.30%) was averagely observed at Ali Akilu Road and Ahmadu Bello Way against a posting speed (65 $kmhr^{-1}$) adopted throughout the study, a short fall of 12.50 $kmhr^{-1}$(19.23 %) was observed at Constitution Road, and surprisingly Independence Way recorded same reduction as Constitution Road, 12.50 $kmhr^{-1}$ and Nnamdi Azikwe Road recorded 12.00 $kmhr^{-1}$ (18.46%) reduction.

Table 2: Observed/Posting Speed against Predicted Speed in Kaduna Metropolis

Location	Posting Speed	Observed Speed	% Difference
Ali Akilu Road	65 KMPH	50.50 KMPH	22.30%
Ahmadu B. Way	65 KMPH	50.50 KMPH	22.30%
Constitution Road	65 KMPH	52.50 KMPH	19.23%
Independence Way	65 KMPH	52.50 KMPH	19.23 %
Nnamdi Azikwe Road	65 KMPH	53.00 KMPH	18.46 %

Source: Field Survey, 2016

Ali Akilu Road and Ahmadu Bay Way have wide carriage ways despite high traffic in the morning and evening. Most motorists at first way (Investment house to Lugard round about and Yakubu Gowon way round about to Magajin Gari) divert to collectors before reaching the end of the road because there are numerous collectors on the two segments. Recording a speed of 50.50 $kmhr^{-1}$ on the two segments is a common phenomenon. Constitution Road and Independence Way like Ali Akilu Road and Ahmadu Bello Way have similar flow characteristics, the segments were well tarred with satisfactory width and do not holds up traffic except at independence way where there was a light traffic control. A speed of 52.50 $kmhr^{-1}$ was observed despite the presence of many state ministries along Independence Way. Presence of high number of tricycles (Keke Napep) was at Constitution Road and that equalized the traffic speed with that of Independence Way affected by light traffic control. See Figure 2.

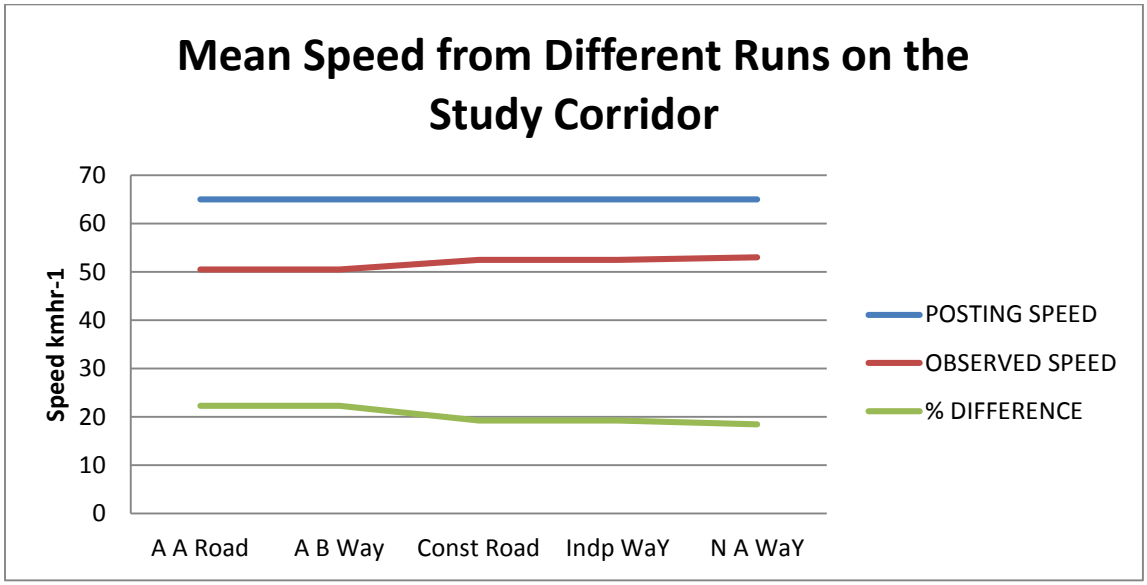

Figure 2: Speed Curve of Five Selected Roads in Kaduna Metropolis
Source: Field Survey, 2016

CONCLUSION

Reduction of speed causes annoyance, depression, tiredness, loss of time and eventual accident in some cases. Traffic delays and congestions virtually affect all commuters and motorists and side frictional variables and events are some of the major cause of congestions and accidents in Kaduna metropolis. Research of this nature is needed to predict speed level and provide a blue print that will reduce the effect to the minimal.

There is the need for government to introduce prioritization of road users (i.e. introduction of truck lanes, bicycle and pedestrian routes, peak lanes, etc.), road hierachisation (i.e. classification of road function), road markings and signs, enforcement devices (i.e. camera, police patrol, etc.), regulation of parking space, congestion charges, fuel prices, traffic restraints (i.e. limiting entry to city centre, pedestrization of city centre, etc.), improvement of public transportation to reduce individual/private vehicle ownership, etc. Also, pedestrian walkways should be built to provide access to safe pedestrian movements. This is because Kaduna metropolis has all of the above mentioned issues.

The Kaduna State Traffic and Environmental Law Enforcement Agency (KADSTLEA) should rise/wise up to enforce laws with regards to unlawful on-street parking, commercialization of roadside by hawkers and beggers in the study area because their presence is nuisance and increase side frictional events.

Motorists, commuters and road users should be educated on the effect of roadside friction in the flow of traffic; this will reduce unnecessary driving on the road and encourage car share application where people that live in the same place and work in the same place share one vehicle instead of all of them driving their individual vehicles.

REFERENCES

Abam, F.I. and Unachukwu, G.O. (2009). Vehicular Emissions and Air Quality Standards in Nigeria. *European Journal of Scientific Research*, 34(4), 550-560.

Aderamo, A.J. and Atomode, T.I. (2011). Traffic Congestion at Road Intersection in Ilorin, Nigeria. *Australian Journal of Basic and Applied Sciences*, 5(9), 1439-1448.

Ajibade, L.T. and Okwori, I. (2009). Assessment of Water Quality near River Asa, Ilorin, Nigeria. *The Environmentalist*, Springer Link 24(1), 1-4.

Amudapuram, M.R. (2014). *India Geospatial Digest*. Road Research Institute, India.

Asakereh, A., Omid, M., Alimardani, R. and Sarmadian, F. (2014). Developing a GIS-based Fuzzy AHP Model for Selecting Solar Energy Sites in Shordirwan Region in Iran. *International Journal of Advanced Science and Technology*, 68, 37-48.

Bashiru, A.R. and Waziri, O.O. (2008). Analysis of intra-Urban Traffic Problems in Nigeria: A Study of Lagos Metropolis. *Indonesian Journal of Geography*, 40(1), 31-51.

Chandra, S. and Kumar, U. (2003). Effect of Lane Width on Capacity under Mixed Traffic Conditions in India. *Journal of Transportation Engineering,* 129, 155-160.

Chetan, R.P. and Joshi, G.J. (2014). Mixed Traffic Speed-Flow Behaviour under influence of Road Side Friction and Non-Motorized Vehicles: A Comparative Study of Arterial Roads in India. World Academy of Science, Engineering and Technology. *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering,* 8(11).

Chiguma, M.L.M. (2007). *Analysis of Side Friction Impacts on Urban Road Links: Case study of Dar-es-salaam*. Doctoral Thesis. Royal Institute of Technology, Stockholm, Sweden.

CUAN (n.d) Cities and Urban Areas in Nigeria with Population over 100,000

Gihring, T. (1984). Interurban Activity Patterns among Entrepreneurs in West African Settings. Human Geography, *Geografisca Annaler* Series B.

Nigerian Highway Code (2017). *Speed Limits on Different Roads and for Different Vehicles.* www.highwaycode.com.ng

Jehu, G. (2002). *Kaduna in Les (ed), Africa Atlases, Nigeria*. Paris, France: 144-145.

National Bureau of Statistics (2015). Motor Vehicular Registration and Personal License Statistics 2013-2015.

NPC (2007). Summing the 2 LGAs Kaduna North/South as per Federal Republic of Nigeria Official Gazette. National Population Commission. Retrieved 2007-05-19.

Rudjanakanoknad, J. (2009). *Attitude of Drivers towards Speed Enforcement Measures on Bangkok Express Ways*. Transport Research Arena 2012.

Yuan, Y., Jiang, R. and Wu, Q. (2007). Traffic Behavior in a Two-lane System Consisting of a Mixture of Buses and Cars. *International Journal of Modern Physics,* 18(12), 1925-1938.