Moonbounce Basics

A Presentation
For

CARA VHF Special Interest Group

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MOON
BOUNCE

MOONBOUNCE BASICS

OR

Everything You Wanted To Know About E.M.E.

AND MORE !

MAIN TOPICS

- What Is E.M.E. ?
- 1st Moonbounce Experiment
- 1st Ham Radio Contacts
- Equipment Requirements
- Locating The Moon

MAIN TOPICS

- Libration Fading & Effects
- Faraday Rotation & Effects
- Doppler Shift & Effects
- Moonbounce Frequencies
- Moonbounce Scheduling
- Moonbounce Newsletters

WHAT IS E.M.E. ?

- **E.M.E is abbreviation for Earth - Moon - Earth**
- **Also known as OSCAR - Ø - by reflecting signals off the for Earth - Moon - Earth moon.**

1ST MOONBOUNCE EXPERIMENT

- First successful Moonbounce experiment accomplished using 110 Mc (now MHz) on January 10, 1946.
- Completed by U.S. Navy between Washington D.C. and Hawaii.

FIRST HAM RADIO CONTACTS

- **On July 15, 1950 Ross Bateman, W4AO and Bill Smith, W3GKP record a short but very weak 2 Meter EME Echo.**
- **2 1/2 years later on January 27, 1953 a series of 2 meter Echoes were recorded in unmistakable fashion!**

FIRST HAM RADIO CONTACTS

Ham Operators employed by government and private institutions begin experimenting with moon bounce.

- **Eimac Radio Club W6HB & W1BU work each other on 1296 MHz in 1960.**

  (In Memory of Bob Sutherland, W6PO (Ex-W6UOV) - SK
  ****Who was at the West Coast end****

- **WA6LET - Stanford University**

  150 foot steerable dish

Stanford University

WA6LET

150 Foot Steerable Dish

FIRST HAM RADIO CONTACTS

- In 1962 KH6UK and W1BU (W1FZJ) make a 2 way contact on 1296 MHz.
- KH6UK used a 28 foot Kennedy Dish and W1BU used a 18 foot Dish. Both used a 1 KW klystron by Eimac.

Hawaii to Massachusetts on 1296 MHz

The operators—KH6UK and W1FZJ. Tommy is shown in his shack, which houses the whole setup. Sam's 1296 gear is in a school bus up on the hill a couple hundred feet away, and the receiver i.f. is fed down to the house.

Above, the antennas at KH6UK and W1BU. KH6UK got his 28-foot Kennedy through MARS, while the eighteen-footer at W1BU came from surplus. Sam's dish tracks automatically. Below, the transmitters. Both used one-kw. kylstrons by Eimac.

FIRST HAM RADIO CONTACTS

- **KP4BPZ - Arecibo, Puerto Rico**

  1000 foot Parabolic Dish

  - Featured in September 1965 QST.

KP4BPZ - Arecibo, Puerto Rico - 1000 Foot Dish

KP4BPZ - Arecibo, Puerto Rico - 1000 Foot Dish

FIRST HAM RADIO CONTACTS

- **After considerable experimenting by a few, VE7BBG and WA6HXW notably contribute much to the art of moon bounce in the early 1970s.**
- **Allen Katz, K2UYH finally completes W.A.C. on 432 MHz - July 1976.**

EQUIPMENT REQUIREMENTS

- ANTENNAS
- RECEIVERS
- TRANSMITTERS
- FEEDLINES

ANTENNAS

- YAGIS
- QUAGIS
- COLLINEARS
- PARABOLICS
- OTHER ANTENNAS

YAGI ANTENNAS

YAGI

- A long boom yagi can display gains of 16 to 20 dBi - depending on boom length.
- Polarity rotation is not easy to change on a long boom.

QUAGI ANTENNAS

QUAGI

- A Quagi generally has more gain per boom length than a Yagi.
- Polarity rotation is not easy to change.

COLLINEAR ANTENNAS

COLLINEAR

- **Has 1 to 2 dB less gain than a Yagi because of reduced boom length.**
- **Polarity rotation *may* be easier to change.**

PARABOLIC ANTENNAS

50 foot homebrew dish

PARABOLIC

- Broad-banded
- Gain increases with frequency
- 55% efficient
- Polarity easily changed
- Not practical on lower bands

OTHER ANTENNAS

HELIX

- Excellent for Faraday rotation.
- Exhibits 3 dB less gain when working toward a linearly polarized antenna.

i.e. elements that are placed either vertical or horizontal.

OTHER ANTENNAS

QUAD ARRAY

- Usually display 1 to 2 dB more gain than a yagi.
- More tedious to build and mount. Doesn’t withstand harsh weather and icing.

OTHER ANTENNAS

RHOMBIC

- **High gain characteristics by utilizing several wavelengths of wire.**
- **Very large and difficult to rotate in both the azimuth and elevation planes.**

TRANSCEIVER REQUIREMENTS

Typical Transceiver/Transverter

- Kenwood TS-711A, TS-811A, TS-790A, TS 2000S
- Icom IC-275A, IC-375A, IC-475A, IC-820 IC-910, IC 1271, IC 1275, IC 706MK2G
- Yaesu FT 726 R, FT 736 R, FT 817/857
- Microwave Modules™ Transverters

PREAMPLIFIER REQUIREMENTS

LOW NOISE FIGURE

- Less than . 5 dB noise figure for 432 MHz and up
- Less than 2 dB noise figure for 144 MHz

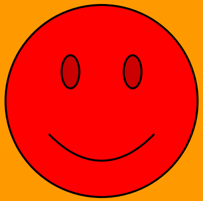
HIGH GAIN PREAMPLIFIER

- Low noise GaAs FET or PHEMT Preamplifier

LINEAR AMPLIFIER REQUIREMENTS

Considering the path loss and other known factors, signals are extremely weak.

YOU NEED ALL THE HELP YOU CAN GET!



USE MAXIMUM LEGAL POWER

FEEDLINE REQUIREMENTS

USE LOW LOSS FEEDLINE !

- Maximum power levels are quickly absorbed if high loss coax is used.

- 3 dB cable loss is equivalent to 50 % power loss delivered to the antenna.

FEEDLINE LOSS COMPARISONS

TIME WAVE ™ LMR SERIES

- LMR - 400 - 2.7 dB/100 feet at 450 MHz
- LMR - 600 - 1.7 dB/100 feet at 450 MHz
- LMR - 900 - 1.17 dB/100 feet at 450 MHz
- √ LMR - 1200 - .86 dB/100 feet at 450 MHz

FEEDLINE LOSS COMPARISONS

OTHER COAX CABLES

- RG 58 B/U - 10 dB/100 feet at 400 MHz
- 8214 (Beldon Foam) - 3.8 dB/100 feet at 400 MHz
- 9913 (Beldon) - 2.6 dB/100 feet at 400 MHz
- √ 7/8” Air Line - .75 dB/100 feet at 400 MHz

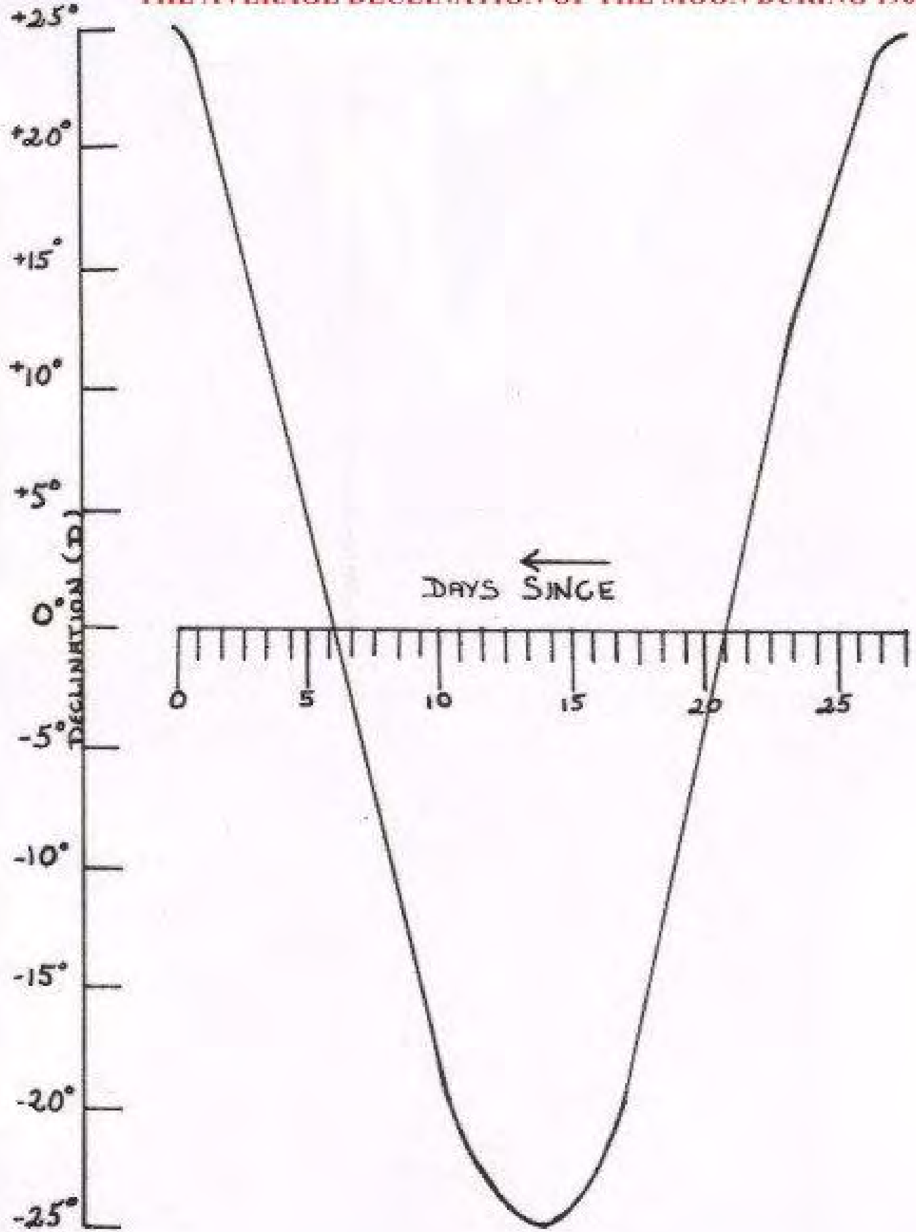
LOCATING THE MOON

- The Moon's Orbit
- Greenwich Hour Angle
- Local Hour Angle

THE MOON'S ORBIT

- The moon orbits the earth approximately every 27.25 days.
- The Orbit follows a sine wave.
- Declination angle of the moon indicate the earth's latitude, and is where the moon will be at zenith.

THE AVERAGE DECLINATION OF THE MOON DURING 1965



GREENWICH HOUR ANGLE

- Is the longitude of the earth's surface where the moon will be at zenith. This is known as the moon's Greenwich Hour Angle (GHA).
- GHA is defined as the angle in degrees west of the meridian.

LOCAL HOUR ANGLE

- **Local Hour Angle (LHA) simply stated is Greenwich Hour Angle (GHA) plus or minus the observer's longitude.**
- **Plus (+) if longitude is east of GHA.**
- **Minus (-) if longitude is west of GHA.**

TRACKING THE MOON

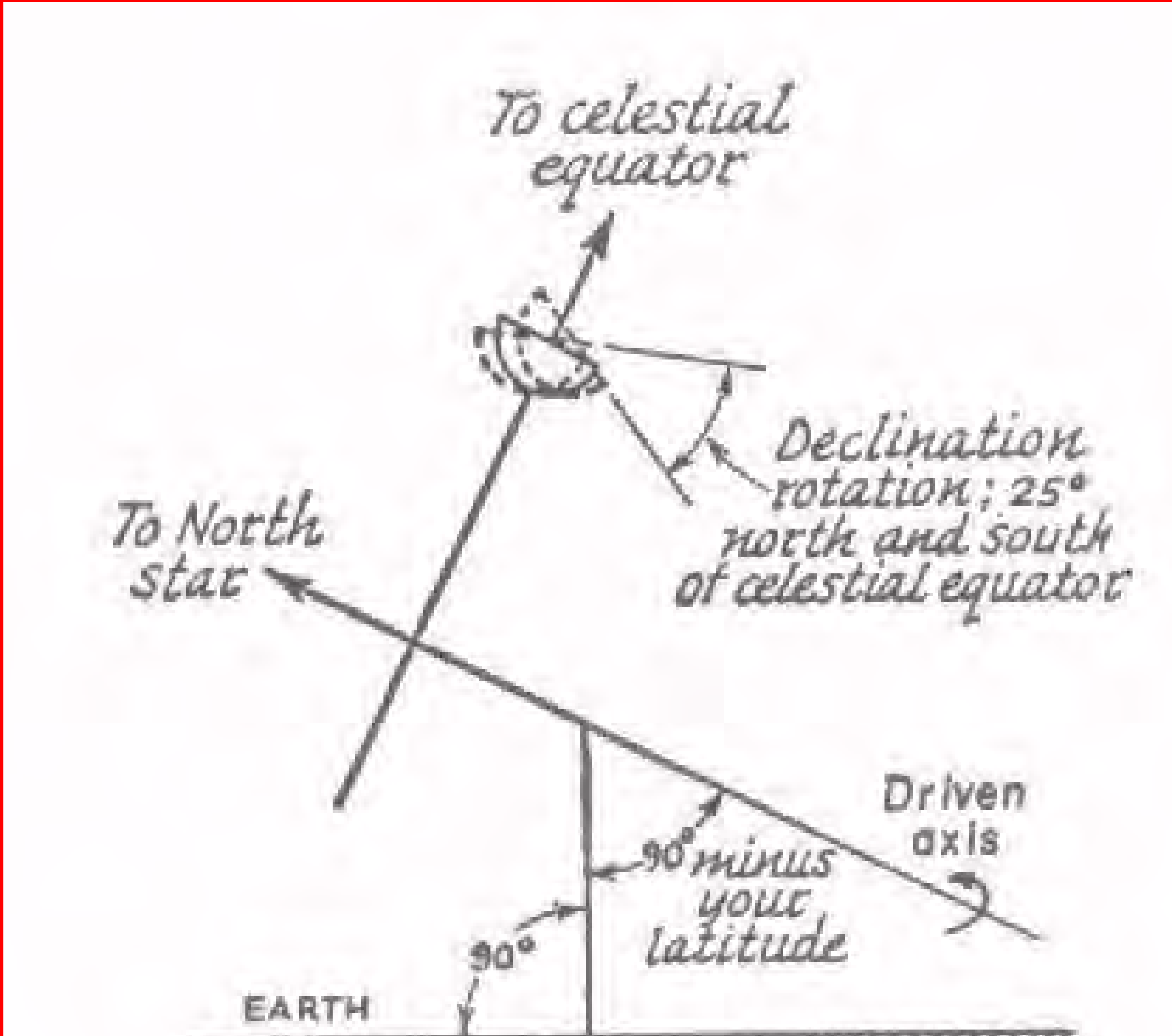
- Azimuth / Elevation
- Polar Mount Tracking
- General Considerations

AZIMUTH / ELEVATION

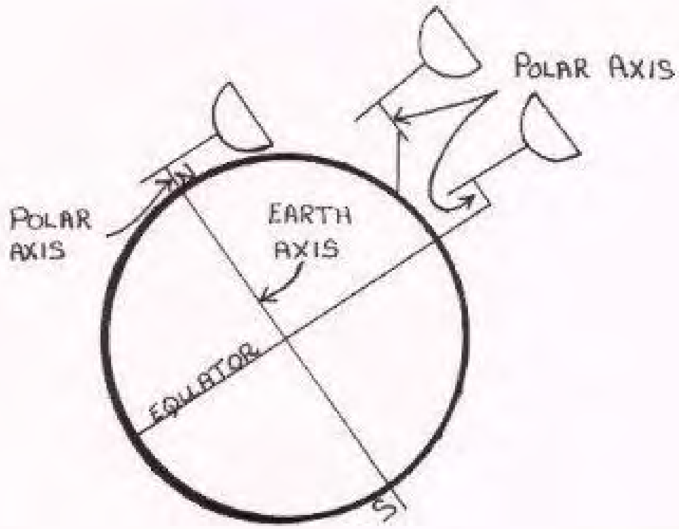
- Antenna systems using Az-El for aiming require GHA and Declination information for conversion to azimuth and elevation coordinates.
- Computer programs can convert GHA and Declination information to degrees azimuth and elevation using Keplerian elements.

POLAR MOUNT TRACKING

- Similar to a TVRO satellite dish setup.
- Once established a TVRO receiving dish declination is *always* fixed.
- A polar mounted dish for moon bounce require declination corrections on a daily basis.



To celestial equator
Declination rotation; 25° north and south of celestial equator
To North star
Driven axis
90° minus your latitude
90°
EARTH


POLAR AXIS
POLAR AXIS
EARTH AXIS
EQUATOR
N
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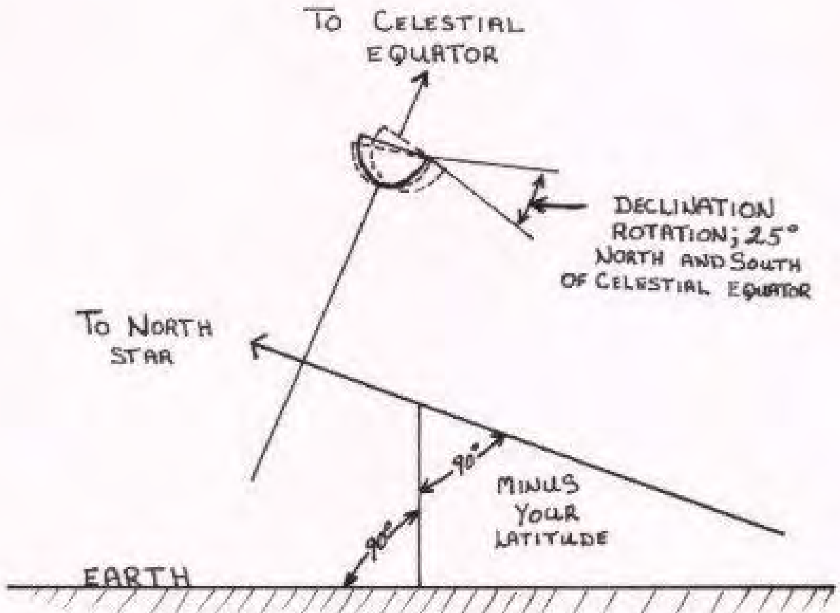

TO CELESTIAL EQUATOR
DECLINATION ROTATION; 25° NORTH AND SOUTH OF CELESTIAL EQUATOR
TO NORTH STAR
90°
90°
MINUS YOUR LATITUDE
EARTH

LIBRATION FADING AND EFFECTS

- **Characterized to a fluttery, ‘rapid irregular fading’ like tropo-scatter.**
- **Fading can be - 20 dB or more.**
- **A random signal can also be enhanced by as much as + 10 dB.**
- **Fading rate changes with frequency.**

Click here to listen to Audio ==>

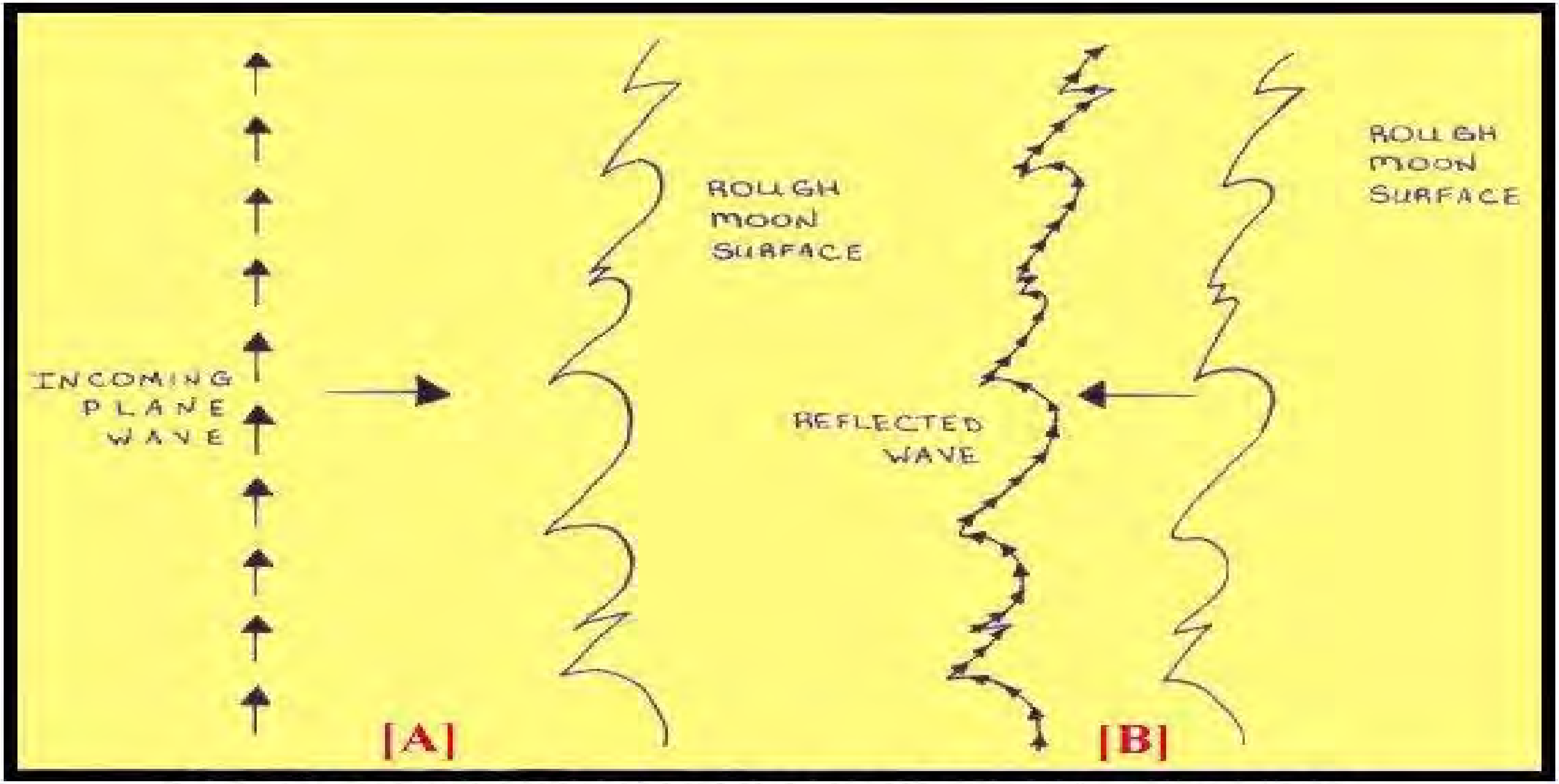
PA3CSG

LIBRATION FADING AND EFFECTS

- **Caused by multi-path scattering of the radio wave from the very large (3200 km) and rough lunar surface.**
- **The combination of multi-path and the relative motion of the earth and moon are called librations.**

Click here to listen to Audio ==> SM4IVE

LIBRATION FADING AND EFFECTS

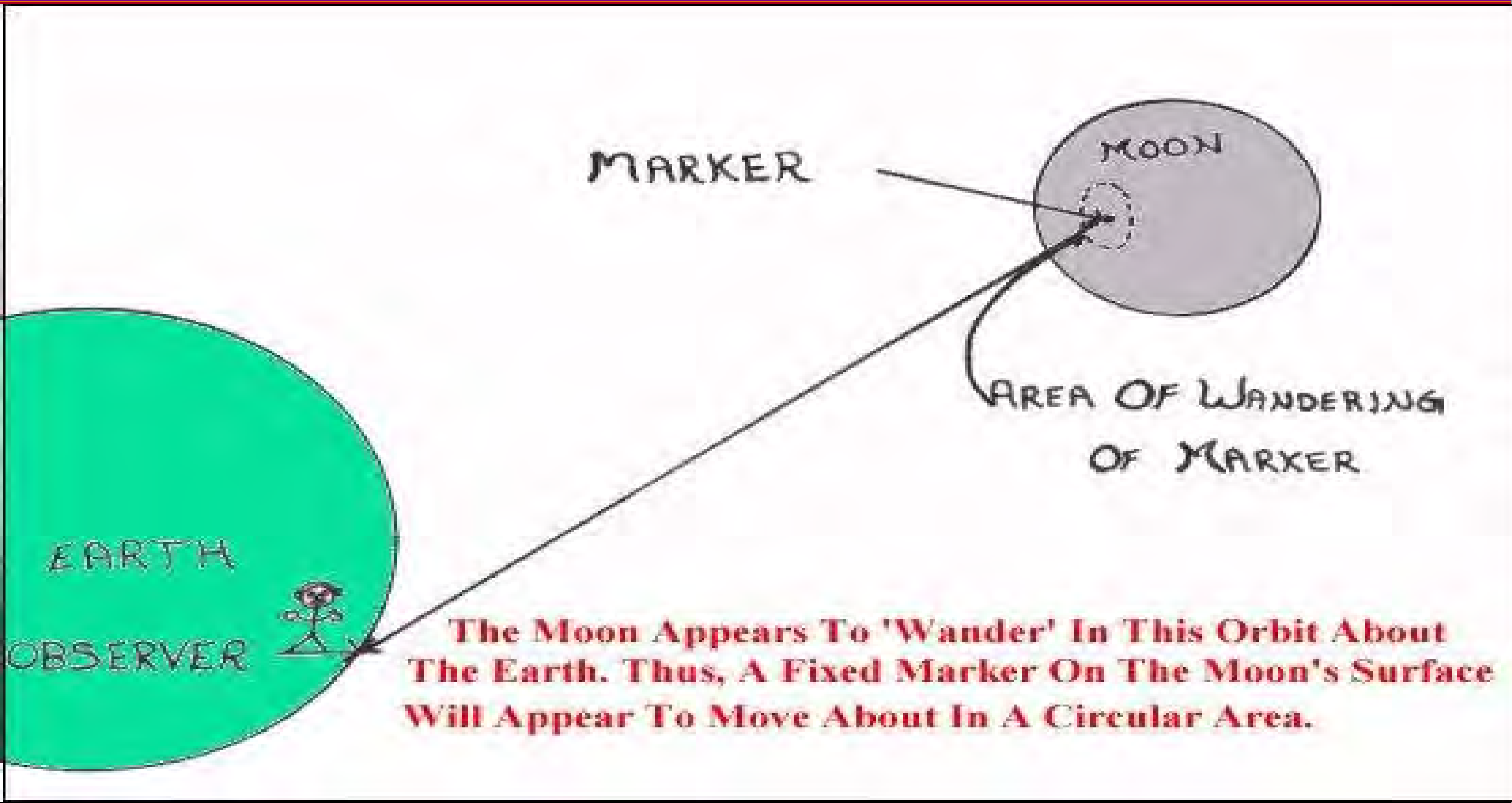


HOW THE ROUGH SURFACE OF THE MOON REFLECTS A PLANE WAVE AS ONE HAVING MANY FIELD VECTORS

LIBRATION FADING AND EFFECTS

- The earth's libration consists mostly of its diurnal rotation.
- The moon's libration consists mostly of its 28 day rotation.
- Moon libration is slow, on the order of 10^{-7} radians per second.

LIBRATION FADING AND EFFECTS



LIBRATION FADING AND EFFECTS

- It is the most troublesome aspect of receiving moon bounce signals.
- Libration fading is far worse than dealing with the enormous path loss and Faraday rotation collectively combined.

LIBRATION FADING AND EFFECTS

- **Libration of the earth and moon are calculable.**
- **“Zero fading” - there does occur a time when the total libration is at or near zero.**

DOPPLER SHIFT AND EFFECTS

- Doppler shift becomes greater as the frequency increases.

- The effect can cause difficulties in locating each other because of the displaced received signal as compared to the transmitted signal.

FARADAY ROTATION AND EFFECTS

- **Michael Faraday (1791-1867)**

- **A phenomenon which alters a light or radio wave polarization when passing through the earth's ionosphere.**

MOONBOUNCE FREQUENCIES

- **2 Metres - 144.00 MHz to 144.050 MHz.**
- **70 Cms - 432.000 MHz to 432.085 MHz**
- **23 Cms - 1296 MHz and 1296.1 MHz**
- **13 Cms - 2304.1 MHz most commonly used frequency.**

MOONBOUNCE SCHEDULING

- It helps to know your own E.M.E. ‘window’ and when your station can see the moon.
- Your E.M.E. window can be translated into GHA and Declination as a constant.
- This information can be used by other stations worldwide - like using the standard UTC system for time.

MOONBOUNCE SCHEDULING

PERIGEE

- Then the moon is closest (225,000 miles/360,000 km) to earth. This provides an advantage of achieving an additional 2 dB gain.

MOONBOUNCE SCHEDULING

APOGEE

- **When the moon is farthest (252,500 miles/404,000 km) from earth. This increases signal losses by an additional 2 dB.**

MOONBOUNCE SCHEDULING

NEW MOON

- Proximity of moon to sun causes increased noise pickup. If perigee (closest to earth) occurs during new moon, schedules should be avoided.

MOONBOUNCE SCHEDULING

AUTUMN & WINTER

- **Signals are better during the fall and winter months than they are in the summer months.**

MOONBOUNCE SCHEDULING

DAY VERSUS NIGHT

- **Signals tend to be better at night than daylight hours.**

MOONBOUNCE SCHEDULING

MOON CYCLES

- The moon follows a 18 to 19 year cycle. In this regard, new moon and perigee are different each year. The moon also follows a sine wave orbit each month.

MOONBOUNCE SCHEDULING

DECLINATION

- **Low moon declinations are not optimum for EME scheduling. Low antenna angles increase antenna noise pickup from terrestrial sources.**

MOONBOUNCE NETS

- **SATURDAY - On 14.345 MHz at 1600 UTC for 432 MHz activity.**
- **SATURDAY - On 14.345 MHz at 1700 UTC for 144 MHz activity.**
- **SUNDAY - On 14.345 MHz at 1600 UTC for 432 MHz activity.**
- **SUNDAY - On 14.345 MHz at 1700 UTC for 144 MHz activity.**

MOONBOUNCE NEWSLETTERS

- **432 and Above E.M.E. News - edited and published monthly by Allen Katz, K2UYH since 1971. E-Mail alkatz@tcnj.edu** to get on the list.
  Carries various activity notes and new improvements made by active moon bouncers, technical articles and 'for sale' items. Also carries schedule of stations looking for EME contacts.
- **http://www.nitehawk.com/rasmit/em70cm.html**

IN SUMMARY

- Amateur Radio moon bounce is 70 years young and is still growing on a daily/yearly basis.
- More Amateurs than ever are enjoying moon-bounce and utilizing more microwave bands.
- Equipment is now easier than ever to procure and assemble into a competitive moon bounce station.

IN SUMMARY

- With more digital software becoming available, such as WSJT developed by Joe Taylor, K1JT, more and more Amateurs are finding it easier to pursue moon bounce activities using very modest antennas.
- The challenges are exciting and rewarding for very little effort or investment.
- NOW, let us have a look at my modest setup.

VE6AFO

70 cm E.M.E.
ARRAY

8 - K1FO - 25 element

Taken during my younger years!!

ANY QUESTIONS

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