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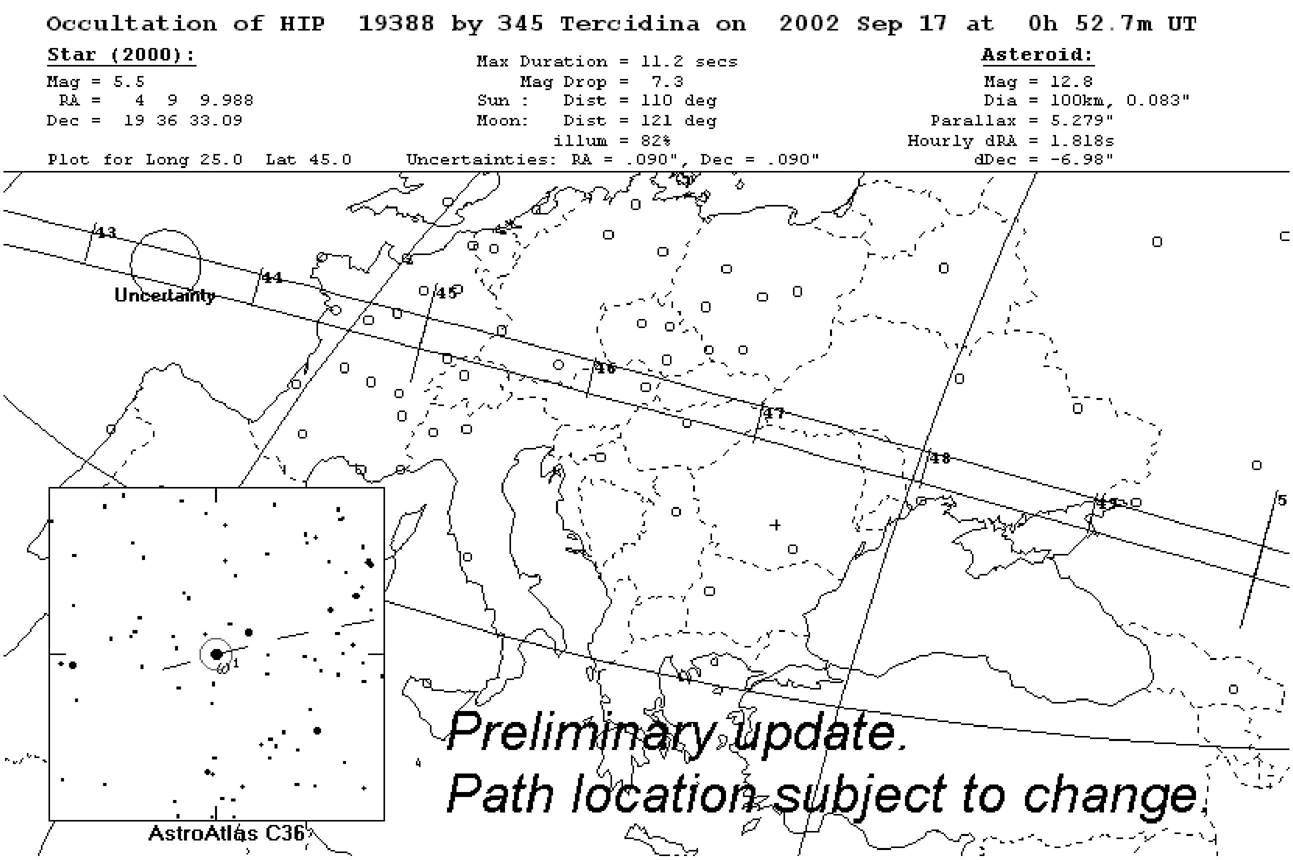

Predicted Path for the Occultation of
HIP 19388 by 345 Tercidina

In this Issue

ON THE COVER:

A very preliminary update for the Tercidina event, based on 3 oppositions 1998-2001 observed by Ron Stone (FASTT) and Bill Owen (TMO). Also added were older observations from transit instrument at Bordeaux-Floirac to have a longer time base. Bill Owen already confirmed that Tercidina is on his list as a high priority target, so another update will follow, weather permitting. There is ~2 path width south shift bringing into game also Austria, Slovakia, Hungary.

Image courtesy of: Jan Manek, jan.manek@worldonline.cz

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Papers explaining the use of the above predictions US$2.50
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Highlights of Observing 366 Lunar Grazing Occultations

Harold Povenmire

As the Moon orbits the Earth each month, it covers up stars along its orbital path. Since the Moon has no atmosphere, the stars appear to snap out rather than dim out. The north and south poles of the Moon define the limits of where the Moon will cover up a star, as seen from a point on the surface of the Earth. Along a path a mile or so wide on the north and south poles of the Moon will be areas where the Moon misses the star, but the mountains sticking out from the Moon will cause the star to blink on and off. These little eclipses are called grazing occultations. When properly observed, timed and reduced, they can be used to refine the orbit of the Moon and to discover previously unknown binary stars.

In 1963, Sky and Telescope published a map showing where the path of the grazing occultation of the star Zeta Tauri would be visible. As the path crossed Ohio, I noticed that it would pass very close to Perkins Observatory near Delaware. On the evening of October 8, I went there and set up to observe this event. I saw the star appear to approach the edge of the Moon, hang there for many seconds and then move away. I had just observed a "MISS." If I had been a quarter of a mile further south, I would have seen the star disappear and reappear behind the lunar mountains. I was disappointed but fascinated by the event and hoped to see others in the future.

In late December 1966, I was visiting the Sacramento Valley Astronomical Society. Several of their members mentioned that there were going to be two grazes on December 18 and 20. I observed the first one, but the poor recording equipment prevented getting any good data. The next day was spent learning how to lay out the predicted limit from the predictions. I also observed the second one, but still did not have good recording equipment, so the data was only of marginal value. By this time, I was hooked on grazes.

The graze program was a product of an astronomy graduate student, David Dunham. He would send out predictions for grazing occultations to interested observers. This program was also endorsed by the U.S. Naval Observatory in Washington, D.C.

My next goal was to set up and lead an expedition for a favorable graze. This came on August 29, 1967. We set up along the railroad tracks in Danville, California just before dawn. We got about 30 timings as the star disappeared and reappeared behind the lunar mountains. After seeing the results, I went around to the other astronomical societies and gave lectures to recruit more observers.

For our next goal, I told our team that we should try to break into the top ten of the best observed grazes. We had many successful grazes, but none that came near the top ten. We were making mistakes, learning from them, and recruiting more observers.

Only a few grazes occur in an area each year. If you are observing grazes, you have two choices: stay close to home and hope for clear skies for those few events, or travel to where the other grazes are. Soon it was routine for us to pack three or four cars with observers and telescopes and take off for a graze 300 miles away to watch a star dance in and out of the lunar mountains for three minutes.

Since man was planning to go to the Moon, it was easy to recruit observers by saying, "This may help us win the Moon race," or "We are trying to get in the top ten best observed grazes. Do you want to join us?"

Our next chance came on September 30, 1967. A favorable graze of a magnitude +6.7 Zodiacal Catalog star (Z.C. 1436) was predicted to pass 20 miles south of San Jose, California. However, that area usually had fog and clouds off the Pacific Ocean at that time in the morning. I made the decision to give a strong motivational talk about how we must drive out into the flat country east of the mountains to get better weather near Mendota, California. This meant a 150 mi drive each way. They decided that it was worth it and we had a large caravan make the trip.

The skies were clear and we had observers set up for a mile across the predicted limit. Nothing could go wrong. Wrong! About half of the observers had a MISS due to a bad star position. The good news was that we discovered that the star was a previously unknown binary and that we had very accurately determined the profile of the northern limb of the Moon. We also obtained about 49 timings which put us in the number ten place in the top ten best observed grazes.

We were still strutting about and bragging on ourselves three weeks later when the Santa Barbara, California, graze team got a very favorable graze and pushed us into eleventh place. Such is life.

My next goal was to lead an expedition for a spectacular graze of a bright star with a thin crescent moon. Shortly after this I had to return to Ohio to finish a Master's degree. I had been informed that there was a very spectacular graze of Antares, with a crescent moon, on January 25, 1968 through central Ohio. In spite of this, I did not get overly excited because winters in Ohio usually mean weeks of cloudy weather. The altitude of this graze was also very low at my location, but more favorable at Washington, D.C. where there was a large graze team. This graze also occurred on the morning of the day after final exams. I had three exams scheduled, so I couldn't really think about much else.

I had laid out the graze near Fairmont, West Virginia, several weeks earlier, but then effectively put it out of my mind. The day of final exams came and a cold front had pushed through with clear skies and temperatures near zero. My area was clear and the Washington, D.C. area was totally clouded. This meant that David Dunham and his team would be joining my little team.

We got the spectacular graze and saw a new phenomena - the spectacular 7 to 10 second dimming of the red giant star. This is caused by the lunar limb slowly cutting into the large angular diameter of the star. We also got many events with the secondary star.

On June 10, 1968, I was scheduled to receive my Master's degree. The only problem was that there was another graze of Antares near Washington, D.C. at the same time. I did the only reasonable thing, skipped the ceremony, and got a small team together and headed for the U.S. Naval Observatory. I met the Director of the Nautical Almanac Office, Dr. Raynor Duncombe. I was very impressed with him and I suggested that I be hired on for a month to get to know how the observatory and their work was carried on and to reduce some of the observations that had been made. He assured me that it was not a workable idea at that time.

We got the graze and I headed for Cape Canaveral to work on Project Apollo. This allowed me to chase grazes up and down Florida and Georgia. On November 16, 1968, after driving all night through the rain, we attempted a marginal graze in the morning twilight near Indiantown, Florida. The weather cleared and the magnitude 7.6 star disappeared early. Shortly thereafter, I noticed a tiny speck of light grazing along the earthshine. We had just discovered that the star Z 11685 (SAO 138613) was a previously unknown binary.

The national goal of landing a man on the Moon was going to be attempted in July 1969. This meant massive layoffs at the Cape, and I was surely going to be one of them. To my surprise, I received a phone call late one night from Dr. Duncombe. He suggested that I come to the U.S. Naval observatory and work for a month doing the work I had suggested. I told him that I wanted to stay to see the launch of Apollo 11 but would then be at his disposal. Apollo 11 landed on the Sea of Tranquility on July 20, 1969 and I was already in the Washington, D.C. area.

I started working on Monday, July 25, 1969. On Thursday, July 28, I had reduced about 15 northern limit grazes and was comparing the results. It was obvious that all of the grazes were shifted in the same direction by about 0.3 degrees. This is the same shift that was known to occur on the southern limb but was unknown on the northern limb. I took my results to one of the sfaff astronomers and showed him the data. He later developed this minor discovery into a major paper and it was published in the Astronomical Journal.

Shortly after starting to work in the Nautical Almanac Office, I saw a tabulation of the total number of grazing occultations observed and the number of scientifically valuable timings made. I found that I had observed more grazes and gotten more timings than any other observer. This had not necessarily been my goal, but rather to be the most accurate grazing occultation observer. However, after seeing the numbers, I decided to try to keep the lead. If somebody else wanted to lose more sleep, get more mosquito bites, buy more gas and have a heart attack sooner than myself, trying to break the record, then I would accommodate them. So far, it hasn't happened.

On August 6, 1969, the waning crescent moon was going to make a spectacular Pleiades passage. I made the trip to near Kansas City, Missouri to join a local group to observe a very favorable graze of 19 Tauri, better known as Taygeta. I had driven nearly straight through from Washington, D.C. and was near exhaustion.

On the graze line, the view was beautiful. Taygeta was a bluish gem with the bright earthshine of the Moon moving up to it. As I saw the star disappear I said to myself, "This was a long drive, but it was worth it." On the sixth event, Taygeta reappeared but at only half brilliance. With an incredible surge of adrenaline I realized that Taygeta was a binary. It was one thing to find that a faint, undistinguished star was a new binary, but not a naked eye star named in Biblical times. This discovery was announced on International Astronomical Union Astronomical Telegram Number 2168.

After the long drive and the spectacular graze I should have been ready to sleep, but with a total of 99 occultation times gotten by the team and the discovery of the binary nature of this star, I couldn't sleep until that afternoon. I still had to drive back.

While this discovery was exciting to me and the other observers, it didn't increase my popularity with the civil servant astronomers. I learned a lot about pettishness from the experience.

In the fall of 1969, I started teaching space science in a junior high school in the Cape Canaveral area. This gave me more opportunities to chase grazes and recruit smart students to be graze observers. These were the sons and daughters of the men who were working on Project Apollo, and they were a superior group of young people.

On March 7, 1970, the path of the total eclipse of the Sun passed just north of Cape Canaveral. Due to the weather, we chose to set up our equipment in the Baptist Cemetery in Jedburg, South Carolina. The cemetery was chosen because it was on the topographic maps. We timed the contacts and duration of totality, and all of our other experiments worked.

In the fall of 1970 I learned that there would be a spectacular graze of Iota Capricorni over the junior high school on December 4, 1970. For five weeks we mobilized every Cape worker, amateur astronomer, student and anyone else who would listen and get a telescope to be on the 4-mile long line we had painted along the railroad tracks going through Titusville, Florida.

The skies were clear and we got 235 accurate timings of the event. I was back in the top ten, but this time we were Number One.

This record held for several years uncontested. On February 10, 1973, there was a favorable graze of Merope across Texas and the Florida Keys. I took my team to the Keys and we got a good observation. The Texas teams were also successful, and the combined number of timings was slightly greater than the Iota Capricorni graze.

In 1974, a friend who was in a sarcastic mood said to me, "You have worked hard on your graze work, but you don't even know what you know." I realized that he was right. I did feel like I had learned a lot about observing techniques and equipment, but it was not written down anywhere. When I realized this, I immediately went to the local drug store and bought a large package of cheap typing paper. In the next 23 days I wrote the manuscript for the Graze Observer's Handbook. Once it was written, I put it away with no intention of publishing it. As events worked out, it was published the next year. The second edition followed about five years later, and together they have sold several thousand copies.

On October 12, 1974, the asteroid (129) Antigone was predicted to occult the magnitude +6.4 star, Z.C. 1281, from south Florida. About two hours later, there was a favorable lunar grazing occultation of the star SAO 118338. I went to the graze site at Cooper Town, Florida early and set up to observe the asteroid occultation. I located the star field and during the critical moment, I observed a brief occultation of the star at 8:00:46.0 U.T. I assumed that I had just observed the edge of the asteroid occult the star. I reduced the data and sent in my observation to the Naval Observatory, Smithsonian Astrophysical Observatory and the Royal Greenwich Observatory. Later astrometry showed that the path of the asteroid had passed over Colombia. For this reason, this observation was not taken very seriously, although Gordon Taylor of the Royal Greenwich Observatory sent a letter of congratulations. This was likely the first recorded occultation of a star by an asteroidal satellite, although it was not recognized at the time.

Later, other amateur astronomers and several photoelectric observations showed that asteroids likely did have satellites. It was in March 1994 that the spacecraft Galileo confirmed a one-mile diameter satellite orbiting asteroid (243) Ida.

August 1975 was a special time. On August 8, 1975 I was doing routine meteor observation from my backyard in Indian Harbour Beach. The skies were poor and I was tired, and not really in the mood to be out with the mosquitoes. I noticed that there were faint meteors radiating from the Square of Pegasus. I checked several meteor radiant catalogs, and did not find any known showers which matched this radiant. The next night they were still active. I didn't know it at the time, but this was the discovery of the Upsilon Pegasid meteor shower.

On August 29, 1975 I had three of my students in the car and was driving through a thunderstorm at the top of the Keys. We were chasing a graze of Z.C. 700. One of my students, Joe Huertas, was driving and I leaned back and was looking at the sky, and noted a bright object in Cygnus. Believing it to be a satellite, I waited to see which way it was moving. After a moment I asked Joe to pull over and I quickly set up the telescope. The star-like object traveled with the stars, and being deep in the Milky Way was likely a nova. I got my call in to Smithsonian Astrophysical Observatory about 15 minutes before midnight. Dr. Marsden said to me, "Where are our American observers? This bright object is nearly in the zenith and yours is the first call I have received." That was the first reported American observation of Nova Cygni 1975. It was exciting to watch the star double in magnitude between midnight and morning twilight. I estimated that by twilight it was exactly magnitude +1.8. At the same time, an observer got a photoelectric recording and he had it at magnitude +1.78.

On Saturday, September 5, 1977, a child slipped off the railing and into the pen of a large crocodile at the Miami Serpentarium. In an instant the crocodile grabbed, mauled and killed the child. It was nationwide news, but especially disturbing in Florida.

On early Sunday morning, September 6, I had a favorable graze of 119 Tauri near Key Largo, and had to drive past where the tragedy occurred. I set up along the famous Route 1 with the Atlantic Ocean on the east and with the Gulf of Mexico to my back. As I set up, I noticed a "log" about 100 yards out in the Gulf. I observed the graze intently, and when it was over I stood up to stretch. I noticed that the approximately 13-foot log was gone, but barely 40 feet from me were two eyes and two nostrils coasting in toward me without even a ripple in the water. I also recognized this very clearly as the largest alligator I had ever seen. My next memory was of bolting out through the traffic on Route 1 and being quite shaken. I never saw the alligator again, but have sincere doubts that he had good intentions.

On September 4, 1981, I got an excited telephone call from one of the student amateurs from the local astronomy club, Jim Getson. He said that a star of first magnitude or brighter was going to be occulted by the Moon. I knew that this was impossible, but quickly set up the telescope and there was a bluish star of approximately magnitude +2.0 near the earthshine on the thin, waxing crescent Moon. I raced to get my stopwatch, WWV time cube and occultation predictions. I glanced over the predictions, and there was no bright star that was predicted to be occulted. The star was now approximately magnitude +4.0. It hung on the earthshine briefly and then snapped out sharply. I got a good timing and then quickly recorded the approximate cusp angle.

The predictions showed a star of magnitude +7.1 and spectral class F2 at the proper cusp angle and at exactly the identical time. The star, SAO 158835, had clearly undergone a massive flare. While the star was still behind the Moon, I got in a call to the U.S. Naval Observatory, David Dunham and the AAVSO. Observers to the west were alerted and they reported that a star of magnitude +5.0 was seen near the bright limb after the reappearance. By the time the news of this event got into good scientific hands and a spectrogram was obtained of the star, it had returned to its normal magnitude and spectral class.

On May 29, 1983, the asteroid (2) Pallas was predicted to occult the bright star, 1 Vulpeculae. I was the regional team leader, and in the months before the event drove 4000 miles and gave 16 lectures to astronomy groups to recruit observers. The skies were clear and our efforts were rewarded, with about half of the reported times due to our efforts. The shape and diameter of this large asteroid was determined very accurately. The reduction of this event was published in a major article in the Astronomical Journal.

On September 12, 1983, a similar, favorable occultation of the star, 14 Piscium, by the asteroid (51) Nemausa occurred over Georgia. A large expedition was organized and successfully observed this event. My wife and I observed this from just north of Forsyth, Georgia. Her station was in a spooky, deserted church cemetery, and mine was across from a deserted house that looked like it had been imported from the "Addams Family." Nemausa was found to have an elliptical shape.

On November 13, 1984, the largest asteroid (1) Ceres was predicted to occult a star over Florida. At this time I was taking courses for a Ph.D. at the Florida Institute of Technology. This university, along with M.I.T. and Lowell Observatory, combined efforts to record this event using photoelectric photometers. We got excellent results, and the diameter was found to be just slightly less than 600 miles. The results of this expedition were published in the journal Icarus.

On March 13, 1989, a graze was predicted over Cocoa, Florida. There had been an aurora borealis the night before. When I turned on the WWV there was only static. I looked carefully at the northern sky and there was no sign of any activity. I walked back to the car and got the telescope. When I turned around, the whole northern sky exploded in a brilliant orange aurora that finally went deep into the southern sky. We got the graze, and the aurora was considered one of the top three of the 20th century.

On August 18, 1990, there was a spectacular grazing occultation of Jupiter on the Mexican border near El Indio, Texas. We set up and observed this predawn event along with several wild hogs and a rattlesnake. Several hours later we attended an IOTA meeting in San Antonio. At this meeting I was elected the regional coordinator for the January 4, 1991 (4) Vesta occultation, which was predicted to cross over Florida. Since the diameter of (4) Vesta was unknown, it was of extreme scientific importance. I sent out 750 "requests for observational assistance" to observatories, planetariums, variable star, meteor, occultation observers and astronomy clubs.

Then the path shifted eastward, so we drove to South Carolina. Then the weather changed, so we had to drive northward to Ohio. We got our equipment set up only minutes before the occultation occurred. We got good data, but the weather that had been 80 degrees F. was now 25 degrees F. This was especially fun since we observed this event with about three layers of T-shirts to keep us warm. Our data, along with that of others, allowed a good diameter for this interesting asteroid to be determined.

On July 3, 1989, the planet Saturn was predicted to occult the bright star, 28 Sagittarii, low in the southwestern sky. This was a very rare event, as no star this bright had ever been observed in occultation by Saturn. At the same time, hurricane Alicia was descending on Florida. We formed a small team and headed westward to drive through the hurricane and get to clear skies. We drove to Ft. Stockton, Arkansas before we found them. When the occultation started, we observed the small particles in the rings to cause the star to brighten and dim. While timing many of these, the star suddenly snapped out completely. A few seconds later it popped on full brilliance. This was undoubtedly caused by a several mile-diameter sized moon embedded in the rings. It did not correspond to any known moon of Saturn, but very likely this planet has many more similar moons.

Another observation of special interest was on September 16, 1991. There was a graze of the bright star, 151 G. Ophiuchi (Z.C. 2524) just south of Jacksonville, Florida. Several groups from around the state had mentioned that they were going to try to attempt this graze. As I drove toward the observing area, the skies began to deteriorate and my expectations for clear weather were not high. At the site, as the Sun went down the wind came off the ocean and dramatically cleared the clouds. The twilight was still so strong that the star was not visible until seven minutes before the first event occurred. After the star was in deep occultation, I noted a faint companion riding along the earthshine. This previously unknown companion remained visible for 119 seconds until the primary star reappeared and flooded it out.

On November 29, 1993, a total lunar eclipse occurred in a star-rich region of Taurus. The predicted limits of two very favorable grazes crossed near the small rural town of Pope, Mississippi. This would allow both grazes to be observed from the same approximate area about 91 minutes apart. An astronomical first could be achieved, as two grazes had never been observed during a total lunar eclipse. I alerted the top graze observers in the southeastern United States and invited them to join our expedition. Veteran graze observers Benny Roberts and Ben Hudgens joined my wife and I, along with several new observers. The skies were clear, the temperature near freezing, and all conditions were nearly perfect. The graze site was at the Pope Chapel African Methodist Episcopalian Church. The magnitude +5.4 star, 53 Tauri, was spectacular as it blinked in and out of the eclipsed lunar mountains up to 14 times at some of the stations. The expedition was a great success. The cumulative total number of grazes observed by the four veteran observers was over 600.

On May 10, 1994 the Great Annular Eclipse occurred over the United States. My wife and I drove 1900 miles dodging weather to Alamogordo, N.M. to observe this interesting event. We had to set up at a major traffic intersection to insure that we could record our coordinates accurately. While we were observing, trucks and traffic sailed along completely normally, quite unaware or uninterested that any event was occurring.

The year 1997 was not a good one for grazes, and I chased all year to get a few marginals. The only good one was of Lambda Aquarii on December 7. We organized the amateur astronomers from all over the eastern United States to attend this graze. For several miles along a rural state road near the Kennedy Space Center, we lined up the observers. That afternoon, a cold front cleared the skies and the seeing was good. The red star was spectacular as it approached the lunar limb. The graze was normal until after midgraze when the events became prolonged, often lasting up to several seconds on the reappearances. Lambda Aquarii was possibly a binary star! The graze was a spectacular success, with the teams recording about 260 timings. The possible binary nature of the star is being observed by the CHARA team using speckle interferometry.

In all long-term observational endeavors like these, there are interesting statistics. Below are some of the more interesting ones

1. When you chase grazes, you can increase your chances of success by only attempting nearby, favorable events. I chase many marginal ones, and over very long distances. My success rate is only slightly above 50 percent. This is due to weather, misses, uncertain data (which is not reported) and instrument problems. I have led more successful graze expeditions than anyone else. I have also led more failed expeditions than anyone else. In all, there have been about 370 of each.

2. The distance to the Moon is approximately 240,000 miles. The distance that has been driven to chase grazes is about 300,000 miles.

3. The combined magnitude of all the naked-eye stars in both the northern and southern hemispheres is approximately equal to 1092 stars of first magnitude, and would be equal in brightness to a star of magnitude -6.6. The total combined magnitude of all the recorded events of all of the grazes that have been reported by this team exceeds this amount.

When the team gets over 100 events when observing a graze of a first magnitude star, this contributes a significant percentage of this total.

4. The expense of chasing grazes for over 38 years has been approximately $50,000. I have often been asked if it was worth the effort. My answer is a firm "I think so." It will probably depend as to how effectively this data is used in the future.

Realistically, I have to admit that if I didn't spend the money on the grazes, I would have spent it on something else, perhaps less productive.

5. I have often been asked if grazing occultation work is amateur or professional astronomy. My answer to this is, "It is professional astronomy which is done by advanced amateurs." Does it matter if a comet is discovered by an amateur or professional? The important fact is that the comet was discovered.

Another question that is often asked is what factors allowed us to achieve the long string of successful observations. Here are some of those factors.

1. When I would receive a batch of predictions, I would go over them carefully and select those which I thought might be worth the effort. These would be marked on the calendar so that no social conflicts would likely occur.

2. It is my firm belief that highly successful, major graze expeditions don't "just happen." Someone was careful in setting up the situation so that factors that could have caused problems didn't occur. The difference between a successful graze and a failure expedition is careful planning. If the event was close, I would make a scouting field trip to look for trouble areas. This might include trees, noisy, mean or loose dogs, power lines, map changes or any other factor which might not show up just by looking at a USGS topographic map, which is probably very outdated.

3. Running out of time is the most common source of observation failure. As a team leader I am always on site more than an hour before central graze to head off problems. My equipment was always assembled and checked 30 minutes before the first event.

4. Equipment failure is the second most common source of observation failure. I always use two backup tape recorders

and two WWV time cubes. Equipment that works fine in your air-conditioned, nicely lit front room does strange things 200 miles away on a country road at 4:30 a.m. One visiting team leader drove over 1500 miles to join our expedition. He arrived only 20 minutes before central graze and asked for the best spot on the line because of the distance he had driven. Because he was an experienced observer, we accommodated him. He drove up after the spectacular graze and said, "Guess I should have checked my batteries." The success rule is, know your equipment and have fresh batteries.

5. The strongest factor for long-term success is the ability to bounce back after several discouraging "cloud-outs." It is very easy to "get mad at the sky" and give up trying for awhile, and therefore lose a couple of graze opportunities. Whiner types and persons without an optimistic attitude or outlook don't last long on graze teams.

Only a person who has been there knows the feeling of driving home with a tape recorder full of exciting events. Likewise, only the person who has been there knows the feeling of driving 300 miles to a graze on a week night and be clouded out, knowing that you still have to drive back and work eight hours.

6. Weather is the one factor which cannot be controlled to a significant degree. My attitude is to "not worry about the weather." In many cases I don't even check the weather forecast. In Florida, the cloud situation can change so quickly that a prediction is of very little value. The Weather Channel is essentially "useless." This is particularly obvious during the time of a solar eclipse or other important event when a cloud cover forecast is essential. During these times they will broadcast an extremely vague or pessimistic forecast, apparently so that if they are wrong, they are unaccountable. If The Weather Channel was as dedicated to accurately forecasting the weather as to selling tires and breaking in amateur broadcasters, it might be of some use. Determine that you will be on your station, ready to observe, regardless of the weather. You still may not get the graze, but your chances are surprisingly good. If you stay at home, you are assured of no success.

After reading this article, if you still think you might like to try graze work, write me a note. I will try to answer your questions. It is a new field and always needs new people and new ideas. Anyone who really tries can do the work. No real math or even an extensive knowledge of astronomy is needed. The feeling of success when you make a good observation, reduce the data and properly report it is very satisfying.

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A Plea for Submissions
John A. Graves, Editor

When I became the editor of *Occultation Newsletter*, my main concern was that I had never edited a newsletter of this size and circulation before. I worried that I would do a professional job of layout and choosing content that was both interesting and informative to the membership.

While I do still worry about these things, my largest problem to date is a lack of submissions of both articles for the body of the newsletter and photographs for the cover.

When I published my first issue of *Occultation Newsletter* I published a very optimistic publication schedule. I was then, and I still am, committed to returning O.N. to a regular publication schedule. This has been hampered to a large degree with the dearth of material to print.

Please consider writing up an article for publication, or submitting a photograph for the cover. While electronic formats are preferred for either type of submission, I will take material in any form and I'll be thankful to receive it!

Some New Members
Art Lucas

The mail moves voluminously through the business office, but we do stop now and then to enter a new member into the log books. Since last report I note these additions:

Bruce Skelley, Castro Valley, CA, obviously a good observing spot.

Harry Newman, Louisville, KY, down by the river, he is yearning for a telescope and, for the moment only has our newsletter and an occasional visit to my dome to urge him on.

Steve Wolfe, Upper Arlington, OH near Columbus, I believe. He has a 5-inch telescope which is better suited for travel than some.

Steve Messner, Northfield, MN has both an 18-inch and 8-inch telescope. He's obviously experienced as he noted in his data sheet that he did not expect to travel with the 18-inch.

Wayne Coskrey, Starkville, MS, has a 6-inch Newtonian and a 12-inch Cassegrain.

Welcome everyone! You'll be getting your new newsletters, predictions and such.If I've missed someone new zing me at **business@occultations.org.**

We attended the ALCON 2002 meeting in Salt Lake City a few weeks ago where we actually saw faces of members.

Spectral analysis and occultation timing

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Abstract : Audio recording is often used as a back-up for standard observation of graze/asteroid/total occultation observations. Such recording can however serve as very accurate time machine even when recorded in very noisy environment. Using computer as an analysis tool extends possibilities of exact evaluation of any tape recording if there is also a time signal recorded in the background. By those means it is no problem to extract times with 0.01second accuracy.

Tape recorders are invaluable tools for recording all moments and comments during a time critical observation sessions. I have often met a situation, reading in reports that “the tape was many times played over and over with stopwatch in hand to determine time (intervals) from the recording”. This is indeed very simple method, but also it is a very subjective method. Is there any more reliable one to evaluate your tape recording? Fortunately I must say – yes, of course – because we have computers ! All you need is a PC with sound card and a piece of suitable software!

Probably first of all would be useful to get some idea, how a sound origins and how a recording is treated in the computer. Any sound is in fact a sort of air pressure changes over time which are detected by our eardrum and consequently transformed in some way in our inner ear and evaluated by our brain. If we stay outside of our head, we can express the air pressure changes over time as a sort of waveforms. The length of such wave represents frequency of a tone, while amplitude of the wave represents loudness of the sound (Fig. 1).

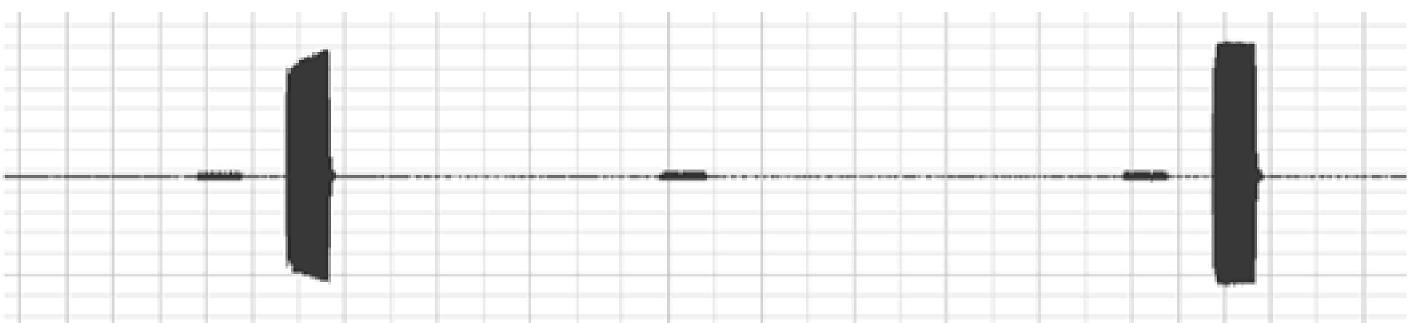

Figure 1. Representation of two beeps of different intensity and frequency. The weaker one (with lower amplitude; DCF receiver) has base frequency 3.5kHz [1], while the louder one (with larger amplitude; DCF based alarm) has frequency 2kHz.

Now lets have a look on Figure 2., where we see a computer sample of a sine wave representing a tone at frequency 333Hz. Sine waves are convenient for computer representation but we must take into account that computers (sound cards) cannot record the waves continuously, but only under certain conditions, which we can name as sampling frequency (time axis), 8 or 16-bit values (of the intensity axis) and mono/stereo recording.

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1 Hz = Hertz. Unit named after German physicist Heinrich Hertz (1857-1894). Periodic event having frequency 1 Hz repeats after 1 second.

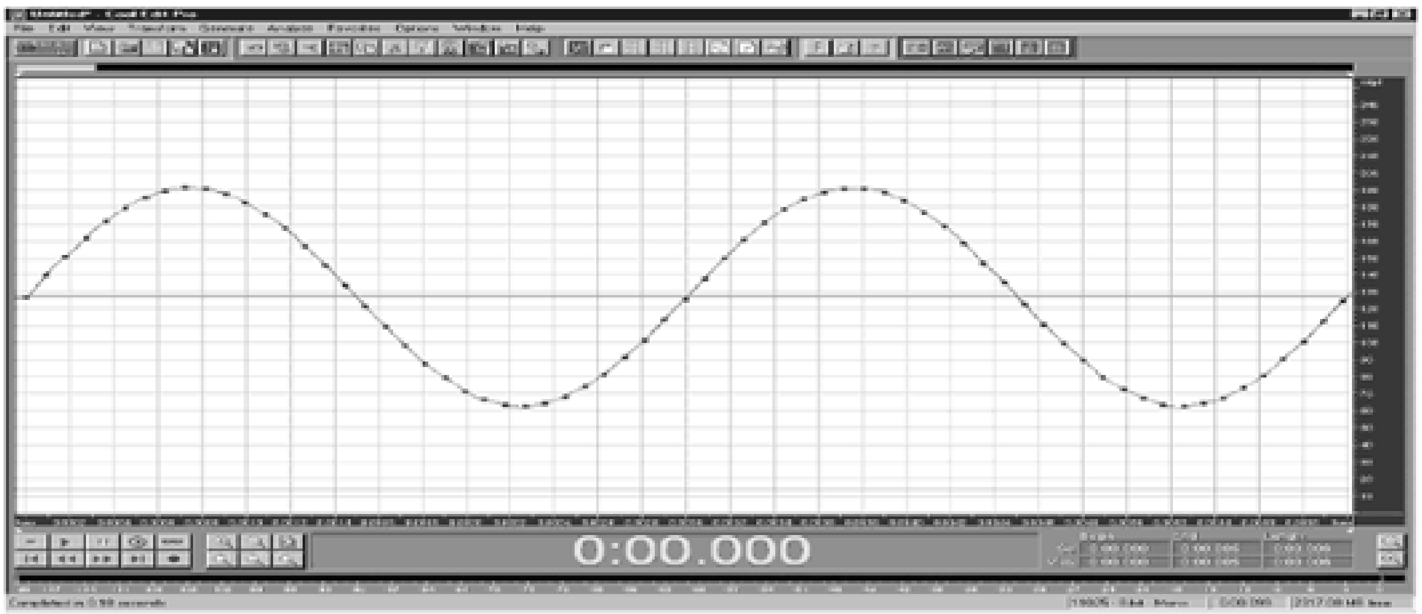

Figure 2. Example of a sine wave in computer at 333Hz with sampling rate 11025Hz and 8bit resolution. This sample is 0.006 seconds long and shows two full cycles of the wave.

Sampling rate is a base limit wrt. what sound frequencies can be recorded into computer. For a sound with frequency 333Hz we have 33 samples per one sine wave (11025/333), which define this wave (Fig.1). For sound frequency of 1kHz we have 11025/1000 = 11 samples which describe the sine wave (Fig.3)

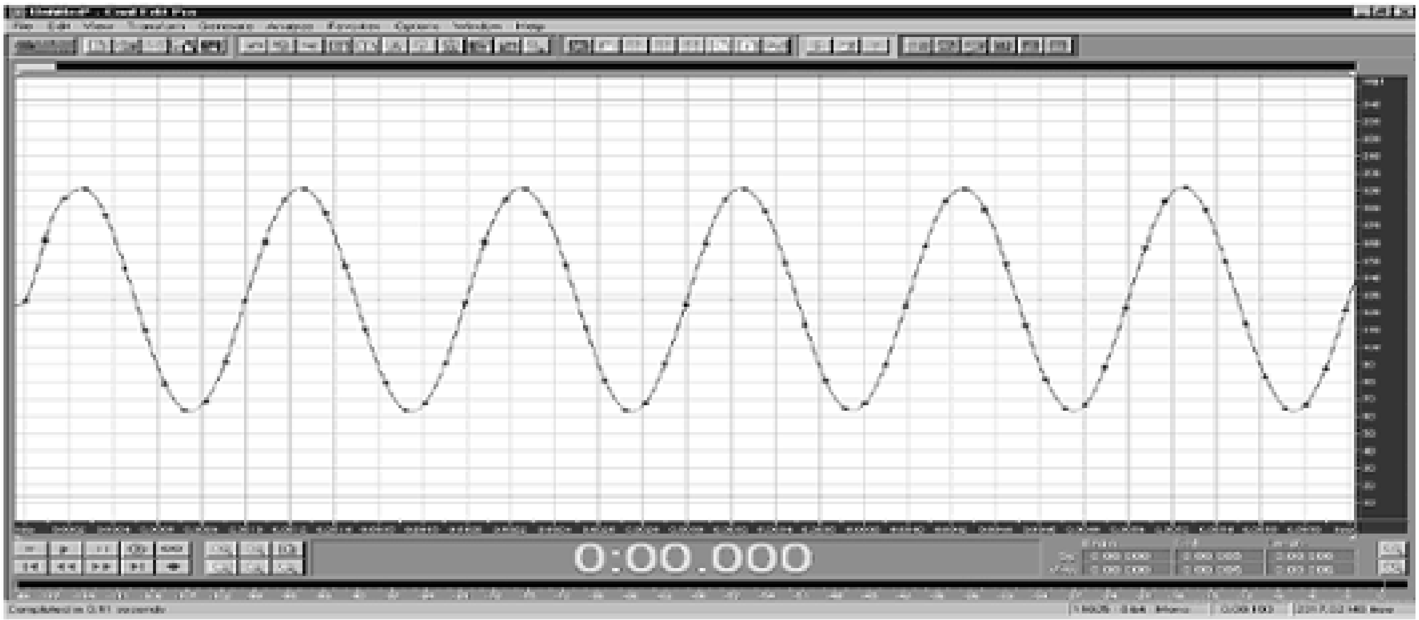

Figure 3. Example of a sine wave in computer at 1kHz with sampling rate 11025Hz and 8bit resolution. This sample is 0.006 seconds long (same as in Fig.2) and shows six full cycles of the wave.

For still higher frequencies there is still less number of points which reliably define the sine wave. There exist a limit of half of the sampling frequency (Nyquist frequency) which define the maximum frequency of sound which can correctly recorded. So at sampling rate of 11025Hz the maximum reliably recorded frequency is 5512.5Hz. Using 8 or 16-bit recording defines how coarse (or fine) we will have the intensity axis or so called dynamic range. With 8-bit setting we get a maximum 256 (= 28) levels of intensity, while with 16-bits we get 65536 (=216) levels of intensity.

For recording of our tape into computer is the most convenient setting a mono recording at sampling frequency 11025kHz and 8-bit resolution. Using these setting we get reasonably good digital recording with rather small file sizes (11kB per one second), which are easy to handle.

Up to now we were talking about sound consisting of single frequencies. In real life the situation is more complicated. Sound of various frequencies and intensities are collected by our ear (or microphone) simultaneously and their sine waves are combined/added together. Is this a problem ? Our brain (the best computer in the world) has solved this thousands of years ago and we hear and distinct all sort of sound frequencies from ~20Hz to 20kHz and various intensities at once. Computer can do this also, with appropriate computer program.

Traditionally the programs you get with your sound card represent sound in the wave forms, similar to those given above figures. From these we can get the timings (if they have a time scale) based on the sound (signal) intensities – similarly as was described in article of Harrie Rutten in OCCULTUS No.59 January 2000 issue (part of his recording is shown in Fig.4). In his article Harrie described how he tweaked the sampling rates, bit depth and volume settings to get best signal-to-noise for the DCF signal beeps to get them out of the background noise to be able to link his voice marks directly to the time scale defined by DCF beeps.

Figure 4. Example of recording by Harrie Rutten. This sample was recorded as 16-bit mono recording at 44100Hz sampling rate, resulting in a 1.1Mb large file for 12.8 second long recording. You can see weak, but regular, time marks of DCF signal together with Harrie's comments 'In' and 'Uit' two times.

True life brings much more noise than signal. Is it possible to get the weak DCF signals more distinct? I have spent some time in search of a computer program capable of real signal analysis fulfilling my needs. After some searches I've sticked to a program called CoolEdit 2000 (or a professinal version CollEdit Pro 1.2). This program allows several approaches to an analysis of a sound recording. So how we can get the DCF signal more distinct? We can :

1) either reduce digitally the background noise which consist mainly from sounds of low frequencies. To do this we must select a small portion of recording consisting of unwanted noise only. From this part we get through 'Noise reduction' a profile of the noise which is in second step removed from the whole recording. Applying this we get for Rutten's recording following image (Fig.5). If the noise level is not too high, the voice is not distorted and you can understand him all he says.

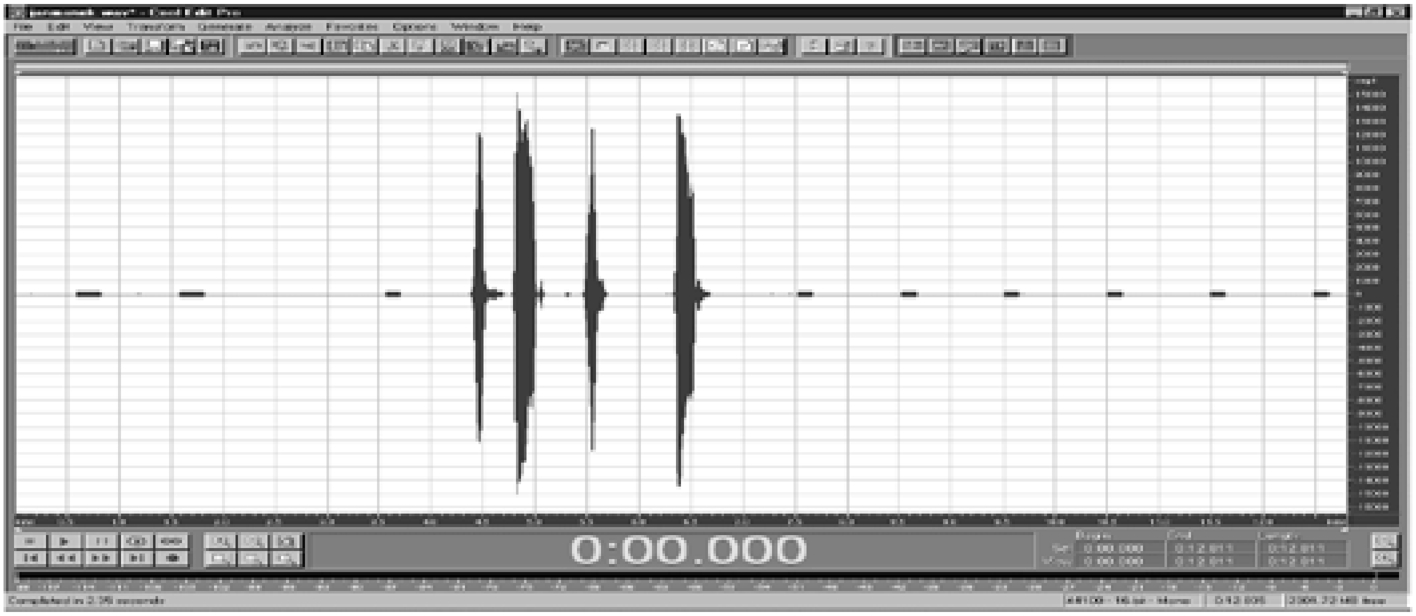

Figure 5. Ruttens's recording after background noise reduction.

2) or you can filter out only frequencies at which the DCF beeps and all other reject. To do this one must know at what frequency Rutten's DCF receiver beeps. This can be easily done by the 'Analysis-Frequency analysis' tool and placing the cursor over a DCF beep. Analysis tool window (Fig. 6) shows frequency analysis at selected point and at first glance one can see a sharp peek at ~4kHz, which is the desired frequency. Now we must create a custom filter which puts through only the desired ~4kHz plus some small window around – this is done by 'Filters-FFT filter' where we define our custom filter. After applying we get something like shown in figure 7. This approach has one advantage – you can get the time signals out of a extremely noisy recording – and one disadvantage – any voice comments of observer are no longer understandable. However this is not a real problem as we can now fix the recording time scale to time scale of the tape and simply return to unfiltered version and link the voice markings there.

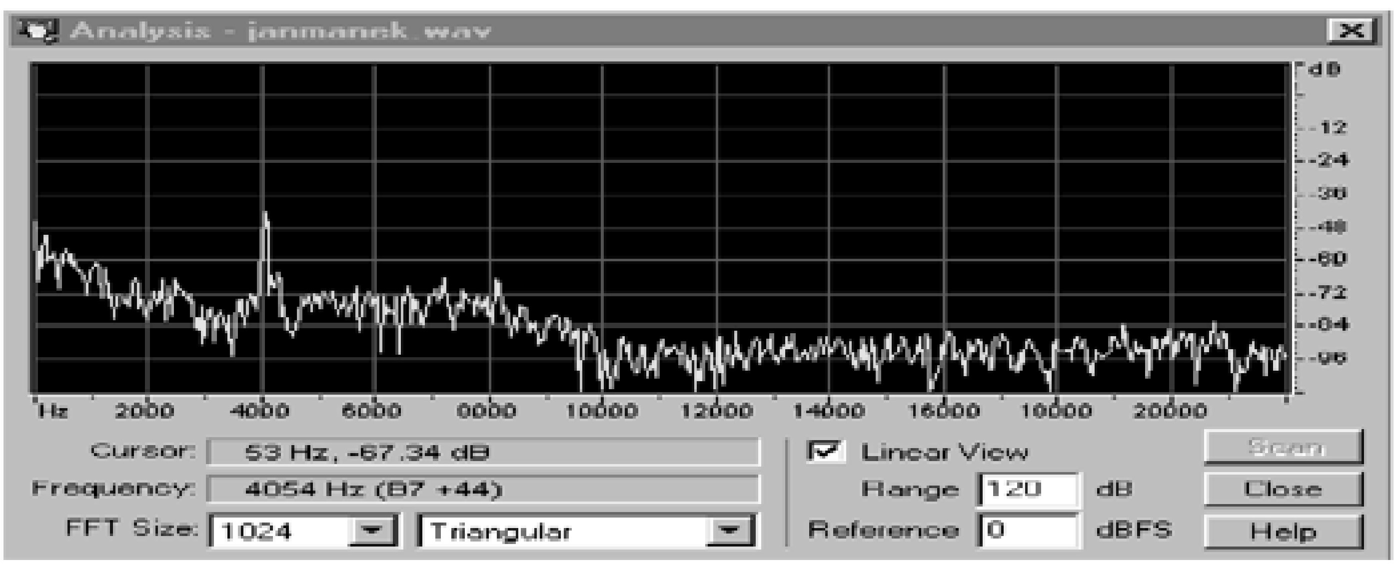

Figure 6. Frequency analysis tool shows sharp peak at ~4kHz, which is frequency of Rutten's DCF receiver.

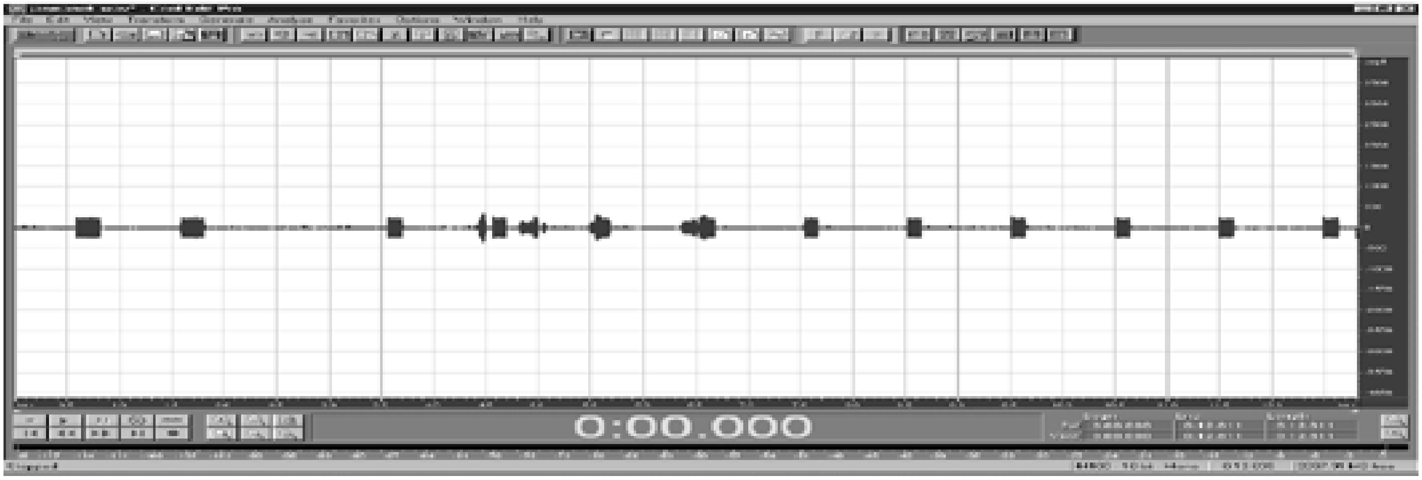

Figure 7. Rutten's recording after filtering only ~4kHz frequencies, anything else is dropped. His voice is no longer understandable, but DCF beeps are very clear now.

O.K. now lets have a look at the last sample (Fig.8) – it is part of a recording from a pearlcorder obtained during Regulus graze near Valašské Meziříčí on April 24th, 1999.

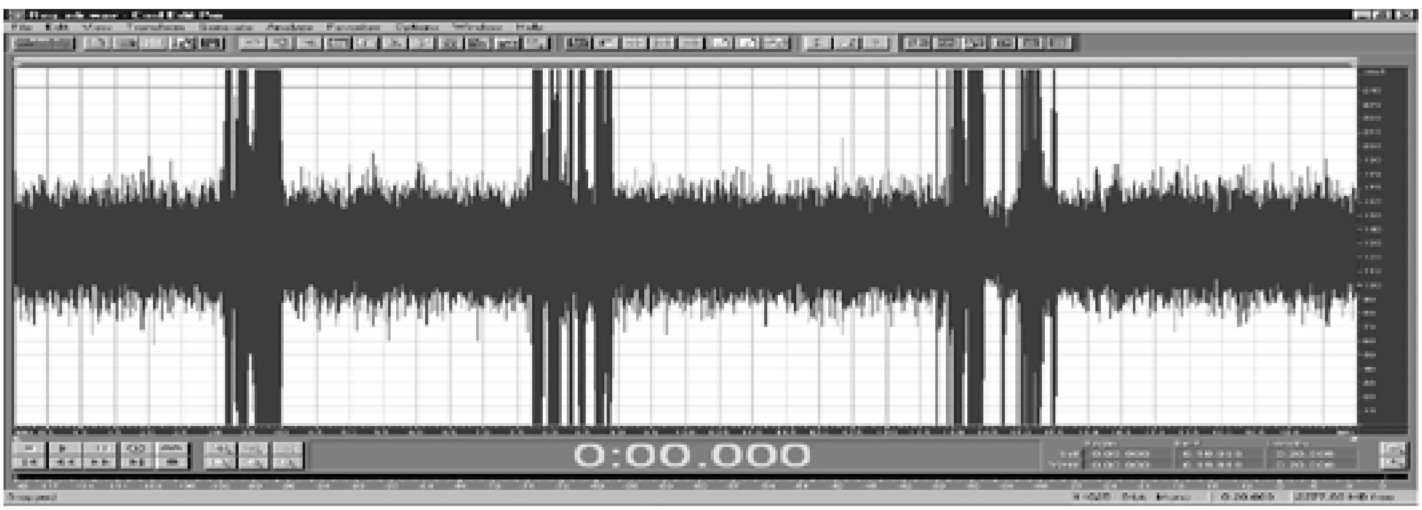

Figure 8. Example of a very noisy recording of Jiří Kubánek obtained during graze occultation of Regulus on April 24th, 1999. No trace of time signal is obvious, although DCF beeps are really present in recording.

As you can see nothing similar to a time signal appears in the recording. At this moment we can't use the background noise reduction (because if we will select by chance a sample with DCF beeps, we would effectively remove DCF beeps from all recording). And we also can't use filtering of certain frequencies, because we don't know the frequency of DCF receiver which Kubánek used in the field. So what to do now ? Although there are some workarounds, CoolEdit offers one tool which I haven't intentionally mentioned yet. It is the possibility to show waveforms not only as waveforms but also in a 'Spectral view'. Using this view CoolEdit performs frequency analysis at all instants of the recording using Fast Fourier Transform. The resulting view (Fig. 9) shows graphically what frequencies are present at any instant during whole recording.

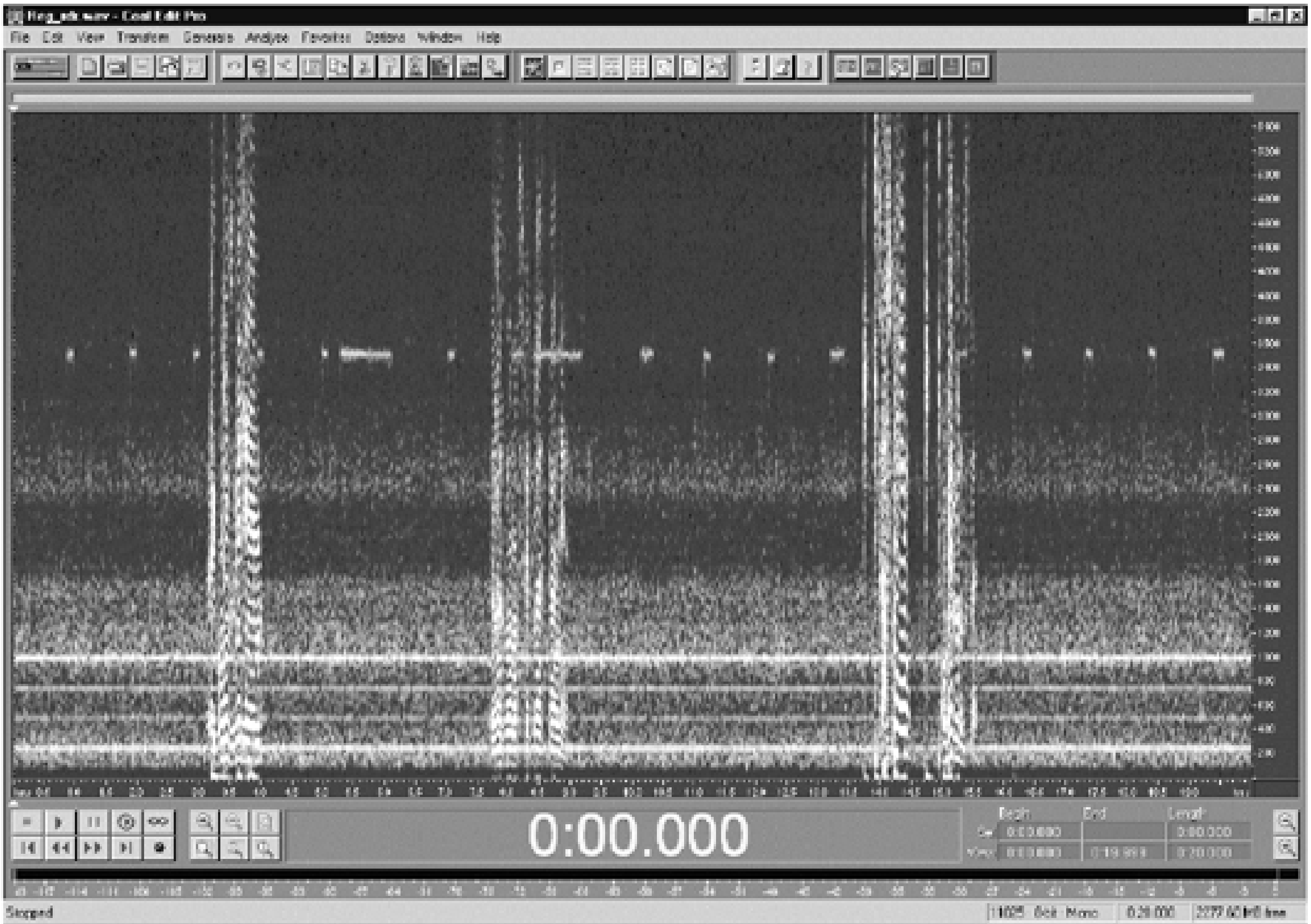

Figure 9. Spectral view of Kubánek’s recording. Despite all the noise DCF beeps are clearly visible and measurable. Mono recording at sampling rate 11025Hz and 8-bit resolution.

Playing with CoolEdit and digital recordings have given me a clue that almost every recording can be evaluated. I’ve tested situations where my DCF receiver was beeping 6 meters away from my tape recorder using it’s internal micro, radio was placed between recorder and receiver or receiver was behind closed door.

The results are fascinating - if there is at least silently hearable time signal irrespective how loud are (noise) sounds recorded around, it still can be evaluated.

And one more bonus – from the digital recording is easy to determine DCF beep lengths. This means that ideally if you have at least one full minute of recording, you have all the time information about the given instant. Decoding of DCF telegram is easy (I’ve wrote a simple program to do that). Only to be sure it’s good to have at least three minutes of recording to avoid possible DCF dropouts.

IOTA's Mission

The International Occultation Timing Association, Inc. was established to encourage and facilitate the observation of occultations and eclipses. It provides predictions for grazing occultations of stars by the Moon and predictions for occultations of stars by asteroids and planets, information on observing equipment and techniques, and reports to the members of observations made.

The Offices and Officers of IOTA

IOTA European Section (IOTA/ES)

Observers from Europe and the British Isles should join IOTA/ES, sending a Eurocheck for EURO 20,00 to the account IOTA/ES; Bartoldknaust Strasse 8; D-30459 Hannover, Germany; Postgiro Hannover 555 829-303; bank code number (Bankleitzahl) 250 100 30. German members should give IOTA/ES an "authorization for collection" or "Einzugs-Ermaechtigung" to their bank account. Please contact the Secretary for a blank form. Full membership in IOTA/ES includes one supplement for European observers (total and grazing occultations) and minor planet occultation data, including last-minute predictions; when available. The addresses for IOTA/ES are:

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IOTA on the World Wide Web

(IOTA maintains the following web sites for your information and rapid notification of events.)

IOTA Member Site
http://www.occultations.org

This site contains information about the organization known as IOTA and provides information about joining IOTA and IOTA/ES, topics related to the *Occultation Newsletter*, and information about the membership--including the membership directory.

IOTA Lunar Occultations, Eclipses, and Asteroidal and Planetary Occultations Site
http://www.lunar-occultations.com

This site contains information on lunar occultations, eclipses, and asteroidal and planetary occultations and the latest information on upcoming events. It also includes information explaining what occultations are and how to report them.

IOTA's Telephone Network

The Occultation Information Line at 301-474-4945 is maintained by David and Joan Dunham. Messages may also be left at that number. When updates become available for asteroidal occultations in the central USA, the information can also be obtained from 708-259-2376 (Chicago, IL).