# Meteor-Scatter Communications

It takes patience and skill, but bouncing signals off meteor trails is an exciting and rewarding means of communication!

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Amateurs who inhabit the VHF bands operate in a different world, propagationwise, from those on HF. The F-layer propagation that makes the HF bands so exciting for long-haul communications visits 6 meters only briefly during peak sunspot years. Above 6 meters, it is nonexistent. For contacts outside the local area—200 to 500 miles, depending on station capabilities—VHFers turn to some pretty exotic propagation modes. One of the more reliable ways to work VHF DX is to reflect signals from meteor trails. To the uninitiated, meteor-scatter communications may seem impossible! This article will take some of the mystery out of this exciting facet of Amateur Radio.

**How Do Meteors Make Propagation Possible?**

The ionized trail of a meteor (see sidebar) can refract a radio signal. The ability of an ionized area to refract a radio wave is dependent on the electron density. A low electron density will have only a moderate index of refraction, while a high electron density will have a large index of refraction.

The effect is also dependent on the frequency of the radio wave. The electron density in a meteor trail is such that radio waves between 25 and 60 MHz are significantly affected. Since the meteor's size and velocity determine the trail size and hence the ion density, it stands to reason that some meteors have more effect than others. A small percentage of meteors create enough ionization to refract 144-MHz signals, an even smaller percentage can refract 220-MHz signals, while a very few can propagate 432-MHz signals.

The signals refracted by a meteor trail propagate just as they would for any other form of ionospheric propagation. The ionization takes place in the E-layer, so the distance covered by meteor-propagated radio waves is similar to that found in E-layer propagation—normally 1400 miles (or less).

The duration of the meteor-produced ionization is also a function of the electron density. Large, fast meteors ionize a lot of air molecules and create relatively dense ionization. The time required for all the ionized air molecules to contact electrons and recombine is much longer than it would be if only a few ions had to combine with electrons. When the meteor first burns up, the ionization is at its greatest. As time passes, more and more free electrons and ions combine, reducing the ion density, until the density finally becomes virtually zero. At that point, no propagation is possible.

**How Does Meteor-Trail Propagation Work?**

Enough of that technical stuff! What's it all mean? As illustrations, let's examine two different meteors.

A relatively large meteor, perhaps the size of a peanut, has a chance to encounter Earth in its respective trips around the sun. While passing close to Earth, the meteor finds itself attracted by Earth's gravity, a force stronger than the sun's gravitational pull (since the meteor is much closer to Earth than to the sun). Upon being drawn in at a high rate, perhaps 40 miles per second, the meteor begins to vaporize (burn), stripping electrons from the vaporized gas.

As meteor ionization goes, the ionized trail is very dense. So dense in fact, that a 220-MHz signal from K1WHS in Maine is reflected and received by W5RCI in Mississippi (they just happen to be listening and transmitting on the same frequency; more on that later). The ion density is so great that the index of refraction is high enough for total reflection of K1WHS's signal. A meteor trail capable of total reflection of a signal at a given frequency is known as an "over dense" trail. The ion density is great enough that signals can't penetrate and be refracted; they're reflected. Of course, frequencies below 220 MHz are similarly affected by this meteor; the index of refraction improves for a given ion density as the signal wavelength gets longer.

W5RCI hears K1WHS for maybe 12 seconds at S8 on his receiver. The signal then starts to fade gradually over the next four or five seconds, until it disappears. No more 220-MHz propagation between Maine and Mississippi until the next meteor.

At the same time all this happened, W1YTW in Maine just happened to be scheduling K5BMG in Louisiana on 144 MHz. The signal from Louisiana rose from nothing to S9 for 20 seconds before fading down over the next 20 seconds into noise. Lower ion density is required on 144 MHz than on 220 MHz for propagation, and the ion density from this particular meteor stayed above the threshold on 220 for only a few seconds. The minimum ion density required for 2-meter propagation could be maintained for a much longer period of time than the higher 220-MHz minimum density level.

A lot happens in Maine. While these two Maine VHFers are working unusual meteor-scatter DX, K1UO is operating the ARRL 10-Meter Contest. In response to a CQ, a collection of W4s, 5s and 9s call K1UO. They're all audible at S7 for a couple of minutes before they gradually fade into the noise. Again, the ionization density in the meteor was sufficient for propagating 10-meter signals for several minutes because the required density level is even lower than at VHF.

Meteors like that in the first example are few and far between. Our second example is more the norm.

Time passes for K1WHS. He hears nothing from W5RCI for 20 minutes. 'Tis a lonely life, that of the 220-meteor jockey.

W1YTW has heard little for the past few minutes. Then he hears just above the noise, "TW from K5B." At least the meteors didn't go the way of the passenger pigeon. The particular meteor that propagated that small bit of information was about the size of a grain of sand. The ion density in its trail wasn't great enough for any type of propagation at 220 MHz; it wasn't even sufficient for reflection at 144 MHz. It was dense enough, however, to refract for a brief moment K5BMG's signal from Louisiana. Only a portion of K5BMG's signal was refracted toward Maine, hence the low signal level. The ion density was low enough that in a short time it dissipated below the level necessary to refract two meteor signals. A meteor trail of this type is known as "under dense."

What of K1UO on 10 meters? He heard a loud, 20-second-long burst from W9RE, with a few more seconds of weak signal.

Earth encounters billions of meteors each day. These billions of meteors are spread over the entire Earth, but meteors appropriately placed for communications between a given set of stations are relatively rare. Of these, only a fraction will be large enough to create an ionized trail adequate for propagation at 2 meters; most of the time this propagation will allow a single letter to be received. Even at 10 meters the duration may be but a few seconds. There will be longer propagation "bursts" of course, but these comprise but a few of the meteors.

**Table 1**
**Major Meteor Showers**

| Shower | Date(s) | Hourly Rate |
|---|---|---|
| Quadrantids | Jan 3-5 | 45 |
| Lyrids | Apr 19-23 | 12 |
| Eta Aquarids | May 1-6 | 12 |
| Arietids | Jun 2-14 | 70 |
| Delta Aquarids | Jul 26-31 | 22 |
| Perseids | Jul 27-Aug 14 | 50 |
| Orionids | Oct 18-23 | 30 |
| Taurids | Oct 26-Nov 16 | 16 |
| Leonids | Nov 14-18 | 60 |
| Geminids | Dec 10-14 | 70 |
| Ursids | Dec 22 | 13 |

### Just What Are Meteors?

Meteors are chunks of material usually associated with the debris from a comet. They travel in highly elliptical orbits about the sun. Every day, Earth encounters billions of these meteors. When the meteor's orbit crosses paths with Earth's orbit, the meteor is drawn by Earth's gravitational field into the atmosphere at speeds of about 22,000 to 220,000 miles per hour!

Any object moving at that high speed is bound to have an effect when it collides with an innocent bystander, such as an atmospheric air molecule. The large amount of kinetic energy possessed by the meteor is converted to heat from the friction of entry into the atmosphere. Atoms on the surface of the meteor are vaporized because of the high temperature. These vaporized atoms are contained by the air molecules. The interaction between air molecules and high-temperature atoms ionizes the air molecules and strips electrons from the vaporized meteor atoms.

A trail of free electrons and positively charged ions is left behind the meteor as it races through the sky. This ionized trail is parabolic in shape, with the burning meteor at the head. The size of the meteor and its velocity determine the size of the trail. A typical meteor is about 1 millimeter in diameter, about the size of a grain of sand. A particle of this size creates a trail head of about three feet in diameter and a trail length of between 12 and 40 miles, depending on speed.

### When Are My Chances Best for a Meteor-Scatter QSO?

The earth encounters meteors that will support communications every day of the year. There are particular times, however, when the number of meteors increases dramatically. Swarms of meteors, probably the remnants of old comet trails, orbit the sun, and Earth passes through these swarms yearly. These swarms cause "meteor showers."

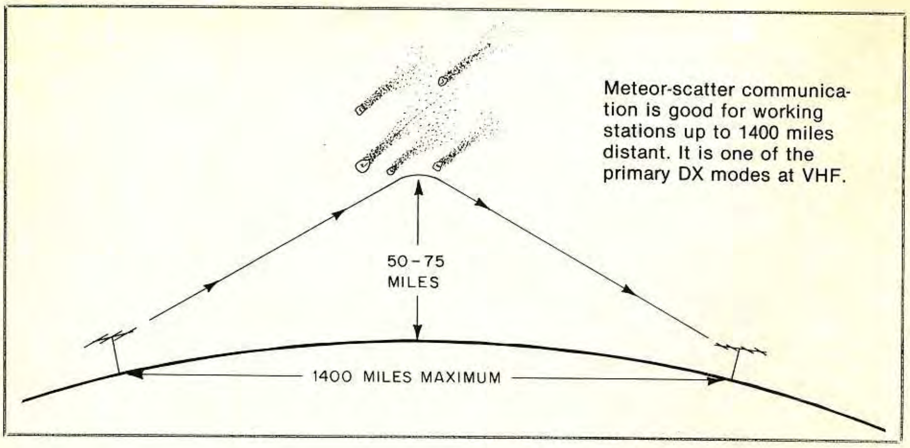
Only a very small percentage of meteors will provide communications between any two points on Earth. Observers use the term "meteor count" to describe the number of meteors that will provide chances for communications between any two points during the course of an hour. The rate depends on the time of day, shower intensity and, of course, radio frequency. During meteor showers, meteor counts of over 60 per hour are quite common on 2 meters, while the count on 10 meters will be greater.

Table 1 shows the yearly meteor showers that are of interest to amateurs. The two largest meteor showers of the year occur in August and December. The Perseids (so named because they appear to emanate from the constellation Perseus) are usually the most productive, followed by the Geminids (emanating from Gemini). Hourly meteor counts on 2 meters of up to 70 and more are quite likely at the peak hours; rates of well over 100 per hour will be seen on 10 meters. Meteor-scatter QSOs are likely, however, during any of the meteor showers listed in the table.

The optimum time of day for meteors is usually in the morning, often around dawn. As Earth revolves around the sun, the "leading edge" encounters meteors first where they are attracted by gravity. As Earth travels further in its orbit, the segments of the planet not in the leading edge are exposed to areas of space that have been "swept clean" of meteors. Only meteors newly arrived to the orbital track can be attracted by gravity for descent to Earth. Consequently, only meteors that have caught up with Earth in its orbit enter the atmosphere.

Burst duration is also greatest around dawn. As Earth revolves around the sun, it has an orbital velocity of its own. At the leading edge of Earth, our planet's orbital velocity is added to the velocity of any meteor attracted toward Earth (much like two cars in a head-on collision; the impact is that much more violent). Burst duration is related to meteor velocity, so the relative velocity improvement found at Earth's leading edge offers an improvement in burst duration.

Some meteor-scatter communication takes place outside of the major meteor showers. Hard-core 6-meter enthusiasts are active most weekend mornings, trying to




work new grid squares or just working random stations for the challenge of it. Savvy VHF-contest operators often use random meteor activity to increase multiplier counts dramatically. Most activity takes place on 6 meters between midnight and dawn. The bigger stations routinely work as many as 100 stations and 40 to 50 grid squares via meteors that they would otherwise miss. Meteor-scatter QSOs are possible on 2 meters most mornings, especially during the summer months. More and more stations are scheduling 2-meter meteor QSOs during VHF contests to work additional multipliers.

### Where Can I Use Meteor Scatter Propagation?

Meteor-burst propagation can be quite useful for both the VHFer and the amateur operating the ARRL 10-Meter Contest (which usually occurs during the Geminids). For the 10-meter enthusiast, those predawn (preionospheric opening) hours (between midnight and seven local time) can be very productive. Contacts can be made out to about 1400 miles. Rather than waiting to work those relatively close-in stations on backscatter (when the long haul is loud) or on a fluke short-skip opening, they can be worked via meteor propagation.

On 6 meters, which is blessed with quality sporadic-E openings each summer and F-layer propagation at the sunspot peak, meteor scatter is widely used. Bursts can be heard on 6 meters every morning of the year. Although most of these bursts are caused by random meteors, they are usually just called "scatter." Even during non-shower periods, bursts last more than a minute—easily long enough to make contact.

On the higher VHF bands, meteor-burst communication is one of the most reliable long-distance propagation modes available. Sporadic-E propagation on 2 meters allows communications over the same paths as meteors do, but sporadic-E on 2 meters occurs infrequently (perhaps a half dozen times a year) and is only vaguely predictable. Auroral propagation is limited primarily to northern latitudes, and tropospheric ducting is a rare event. Moonbounce provides the most consistent communications link, but it requires above-average station sophistication. Meteor-burst communication is the prime propagation mode for 144- and 220-MHz DX hunters. On 432 MHz, at least three contacts have been made; meteor-burst propagation certainly presents a challenge to the 70-cm operator when bursts are weak and are infrequent.

### How Do I Make Contact?

Generally, meteor-scatter QSOs are made on SSB. Some operators prefer high-speed CW, and there is some experimentation with packet radio. Although techniques vary from band to band, there is one basic guideline for making meteor-burst contacts: Keep all transmissions as short as possible. Burst duration may be as long as a few minutes or as short as a few seconds. The "opening" time is limited, so time efficiency is very important. The critical aspect is to get call signs and report through—it is easy to make the mistake of talking right through the opening.

Much of the activity on 10 and 6 meters is done randomly. That is, people who enjoy meteor-scatter contacts call CQ or listen for others calling. A good approach for calling CQ on these bands is to call a single CQ, followed by your call sign, repeated two or three times. In that way, even short bursts will convey the information: CQ FROM K1JX. When answering such a CQ, it is usually best to give the other station's call and your own in phonetics once: K1JX FROM W9 ROMEO ECHO. The best response K1JX could give would be W9RE 59 CONNECTICUT and stop. Then immediately W9RE should say ROGER, 59 INDIANA. Upon receipt of W9RE's information, K1JX could say ROGER, QRZ FROM K1JX.

An entire QSO from CQ to QRZ, with complete reports, call signs and acknowledgment (the necessary components for a legitimate QSO) can be completed in about 12 seconds. Usually, a single meteor can sustain ionization for an adequate period of time to complete a contact on 10 meters. Occasionally, multiple bursts are required for both parties to complete the contact. Again, the key is to keep transmissions short and concise. Repeating information unnecessarily is a waste of time, and time is propagation!

Six-meter meteor-scatter operation is similar to that on 10 meters. Since bursts are shorter, it may take several tries to convey all of the information needed to complete


DON'T GIVE UP TOO EASILY!

a QSO.

The story is different on 144 and 220 MHz, however. Because bursts are short and infrequent, most 144-MHz and virtually all 220-MHz meteor-burst contacts are made by schedule or at least through some standardized operating sequence. Schedule frequencies are coordinated in advance down to the kilohertz, as are transmission and reception times. The need for listening and transmitting on the right frequency is obvious. Standardized and agreed-upon-in-advance transmitting and receiving periods keep both stations from simultaneously transmitting or receiving and thereby wasting a possible meteor burst.

Throughout the United States there is a simple accepted standard for transmission timing. Each minute is broken up into four 15-second periods. The station at the eastern end of a potential contact transmits during the second and fourth 15-second period of each minute, and the western station transmits during the first and third period of each minute.

A VHF meteor-scatter QSO may not be completed on a single burst. In fact, since it may take an hour or more for a burst to occur that is good enough to complete a QSO, standards have evolved to judge the validity of a contact. There are three necessary contact components for a contact to be valid. The first is identification of call signs—complete identification. Each station must hear his call sign and that of the other station. The second part is exchange of some sort of information, both ways. The last is acknowledgment, in both directions, of receipt of exchanged information. The integrity of a contact can be considered honored only by strict adherence to this standard. There are those who will try to convince you that something less than this is acceptable. Consider this: Does this person want to really make a contact or does he only want a QSL card? Is the satisfaction in the cardboard or in the accomplishment of a difficult contact?

At the beginning of a schedule, each operator sends calls for the entire 15-second transmit period. The station being called is sent first, followed by the calling station, like this: W9RE K1JX, W9RE K1JX, W9RE K1JX. Some of the most experienced operators "break" about halfway through the 15-second transmission in case a meteor burst is taking place. By doing this, even short bursts can be used successfully.

Once an operator hears a complete set of call signs, he can send the unknown information along with calls. A common system used for years is the S report. A report from S0 to S5 is given based on the burst duration. Unfortunately, the standard for what the different S numbers mean in terms of burst duration have become muddled over the years. As a result of this, the Central States VHF Society, a group of serious VHFers throughout the United States, has advocated the exchange of state or province name in place of an S report. Each system has its merits, but the important thing is for scheduling stations to agree on a particular system. (Random contact seekers don't have that luxury. It adds to the challenge.) In any event, the 15-second transmit period would sound something like this: K5YY K1JX S2, K5YY K1JX S2.

Call signs must be sent continually until you copy the signal report from the other station. You know that the other station has received your call signs when you begin to hear a signal report. A signal report can only be sent upon receipt of complete call signs. Except for an occasional call-sign announcement to satisfy FCC identification requirements, calls needn't be sent from this point on; they only waste burst time.

When you receive a signal report, you can start to send the acknowledgment. This is simply sent in the form of ROGER on voice or R on CW. You must continue to send signal reports until you receive acknowledgment. Then, only the acknowledgments are required. The process is continued until the acknowledgments are received in both directions. The contact is then complete.

Description of the contact sequence may make the process seem difficult and complicated. In practice, it isn't. Since an example is worth something less than a thousand words, here is how a typical schedule between K1JX and KØALL might go. In this case, K1JX receives during the first and third 15-second sequences (00 to 15 seconds and 30 to 45 seconds after the minute) and transmits during the second and fourth.

(As heard at K1JX)

(RX) 0900 (00)-0900 (15)—"Hiss ..."

(TX) 0900 (15)-0900 (30)—KØALL K1JX, KØALL K1JX, KØALL K1JX, BREAK ... (momentary hiss) ... KØALL K1JX, KØALL K1JX, KØALL K1JX

(RX) 0900 (30)-0900 (45)—"Hiss ... ØALL K1JX ... Hiss ..."

(TX) 0900 (45)-0901 (00)—KØALL K1JX, KØALL K1JX, KØALL K1JX, BREAK ... (momentary hiss) ... KØALL K1JX, KØALL K1JX, KØALL K1JX

Some time later

(RX) 0911 (00)-0911 (15)—"Hiss ... JX KØALL K1JX KØ ... Hiss"

(TX) 0911 (15)-0911 (30)—KØALL K1JX S2, KØALL K1JX S2, BREAK ... (momentary hiss) ... KØALL K1JX S2, KØALL K1JX S2

(RX) 0911 (30)-0911 (45)—"Hiss"

Continues like this until sometime later

(RX) 0913 (30)-0913 (45)—"Hiss ... K1JX KØALL S2 K1JX KØALL S2 K1JX KØ ... Hiss"

(TX) 0913 (45)-0914 (00)—ROGER S2, ROGER S2, ROGER S2, ROGER S2, BREAK ... (momentary hiss) ROGER S2, ROGER S2, ROGER S2, ROGER S2

(RX) 0914 (00)-0914 (15)—"Hiss ... S2 S ... Hiss"

(TX) 0914 (15)-0914 (30)—ROGER S2, ROGER S2, ROGER S2, ROGER S2, BREAK ... (momentary hiss) ROGER S2, ROGER S2, ROGER S2, ROGER S2

Continues until some time later

(TX) 0917 (15)-0917 (30)—ROGER S2, ROGER S2, ROGER S2, ROGER S2, BREAK ... (momentary hiss) ROGER S2, ROGER S2, ROGER S2, ROGER S2

(RX) 0917 (30)-0917 (45)—"Roger Roger Roger Roger Roger Roger Roger ... 73, 73"

(TX) 0917 (45)-0918 (00)—73, 73 RON BREAK; "73 Clarke"

Calling CQ for random contacts on 2 meters is a similar process. The time sequences are the same, except that you call CQ instead of another station during the appropriate 15-second period (CQ K1JX, CQ K1JX ... ). The greater challenge here lies in identifying the caller, exchanging reports and acknowledging, all without any prior knowledge. Usually, random CQing is carried on at 144.200 and 5 kilohertz increments up and down from calling frequency (144.195, 144.190, 144.205, 144.210, and so on). There is so little 220 meteor-scatter activity that almost all work there is done by schedule.

You can get started by listening to 6 meters during any VHF contest or on most weekends. If you hear stations calling CQ, give them a call—just be ready for a quick reply. If you're only on HF, listen to 10 meters during the ARRL 10-Meter Contest. And you can try 2 meters during the meteor showers. No matter what your planned activity, remember one thing: Keep it short and sweet. QST

**What Kind of Equipment Do I Need to Work Meteor Scatter?**

As with any weak-signal work, a sensitive receiver, legal-limit power amplifier and high-gain antenna will make meteor-scatter communications easier. If you don't have these things, not all is lost!

For 10-meter work, all you'll need for many meteor-scatter QSOs is a standard 100-W transceiver and a three- or four-element beam. If you have a kilowatt amplifier, you'll be able to work even more stations.

At 6 meters, you can use as little as 10 W and a small Yagi to work some of the "big guns"—if you're patient. You'll enjoy a slew of contacts with 100 W and a four-element beam. If you run high power and have a good receiving preamplifier, you'll practically be able to ragchew with other big stations.

On 2 meters, the average station consists of a multimode transceiver, 100- to 160-W amplifier and a single long Yagi. You'll be able to make many a schedule with a setup like this, but if you're interested in random contacts you'll probably want more. A good station for that type of operation might include a pair of long antennas, a low-noise preamplifier and a 500- to 1500-W power amplifier.

Signals at 220 MHz are much weaker, so a better station is desirable. You'll want a low-noise receive preamplifier and a pair of antennas. Although contacts are possible with a 100-W "brick" amplifier, a tube-type amp capable of 300-500 W or more is a big help.