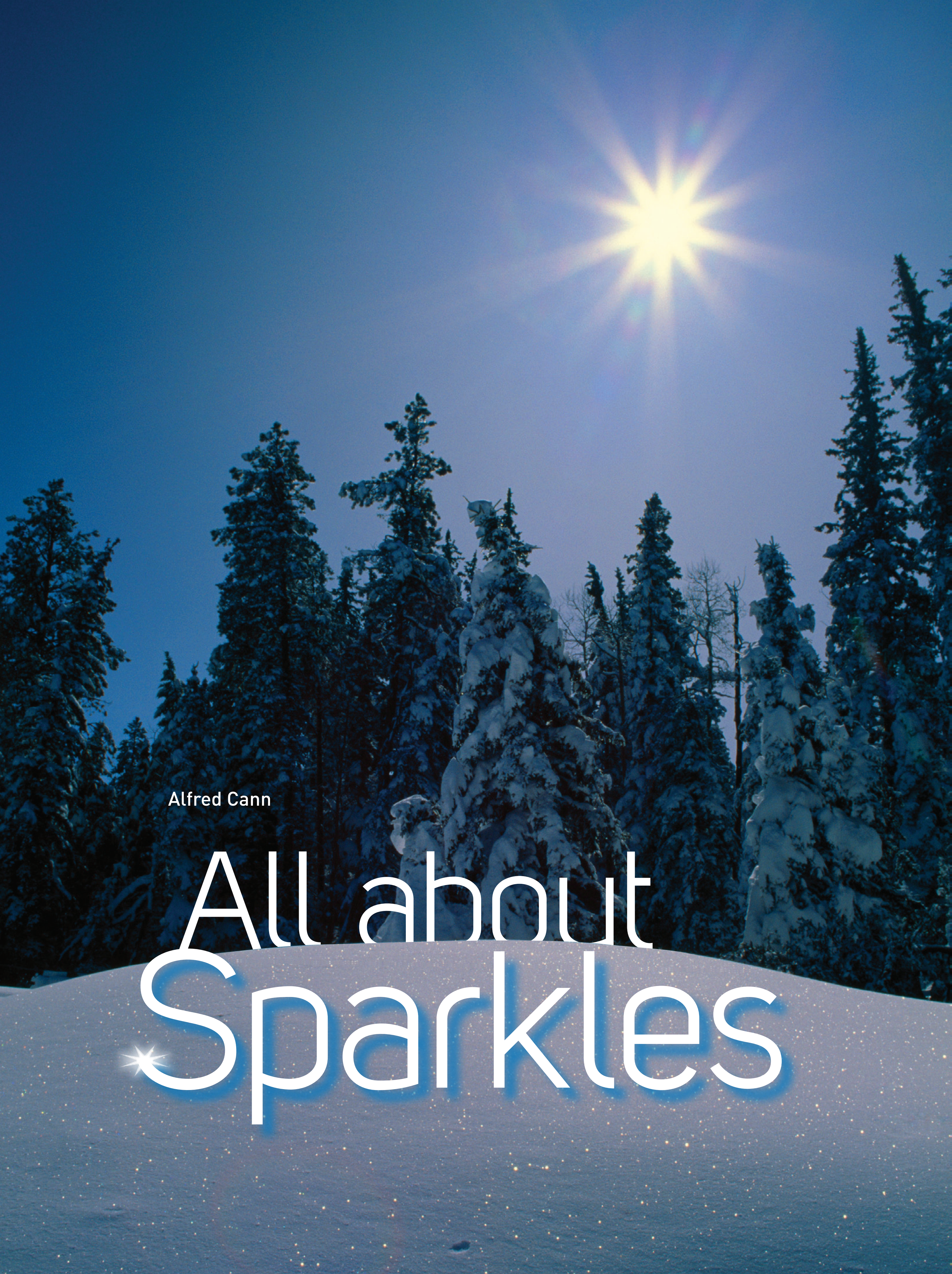
Alfred Cann

# All about Sparkles



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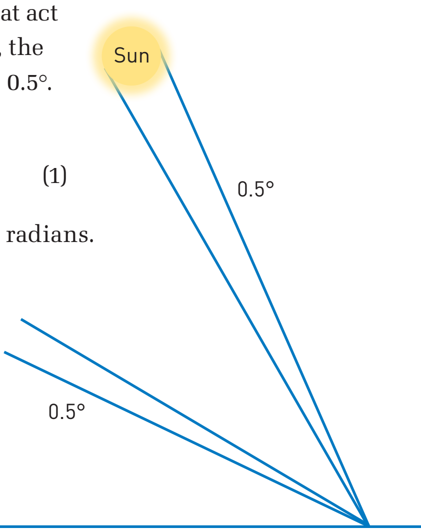
## Sparkles are a magnificent manifestation of optics in nature, and nowhere are they as abundant as on freshly fallen snow. Because they evade our depth-perception mechanism, sparkles have an otherworldly quality that makes them seem to float indeterminately rather than appearing on any surface or at any altitude.

Whether they're caused by snow, diamonds or glitter, sparkles are always dazzling to behold. The glittering, ephemeral effect they have is caused in part by their rapid appearance and disappearance. But that is not the whole story—or even most of it. The startling impression they induce is caused by the inability of our depth-perception mechanism to process them. Snow crystals have flat surfaces that act as tiny mirrors, reflecting the sun. Considering the mirror width negligible, the beamwidth of these reflections is equal to the angular diameter of the sun, 0.5°. The width of the illuminated spot at the eye is given by

$$w = r\theta, \qquad (1)$$

where $r$ = the distance from the mirror to the eye and $\theta$ = the beamwidth in radians.

This can be much smaller than the typical distance between our two eyes. For example, at 3 m (10 ft), the spot width is about 2.5 cm (1 in.). Consequently, each sparkle is generally seen by only one eye, and thus the two eyes see different sets of sparkles. That prevents the depth perception system from fusing the two images and determining the distance to any one sparkle.




**MIRROR REFLECTION**: Snow crystals have flat surfaces that act as tiny mirrors, reflecting the sun. Considering the mirror width negligible, the beamwidth of these reflections is equal to the angular diameter of the sun, 0.5°. The width of the illuminated spot can be much smaller than the typical distance between the two eyes.

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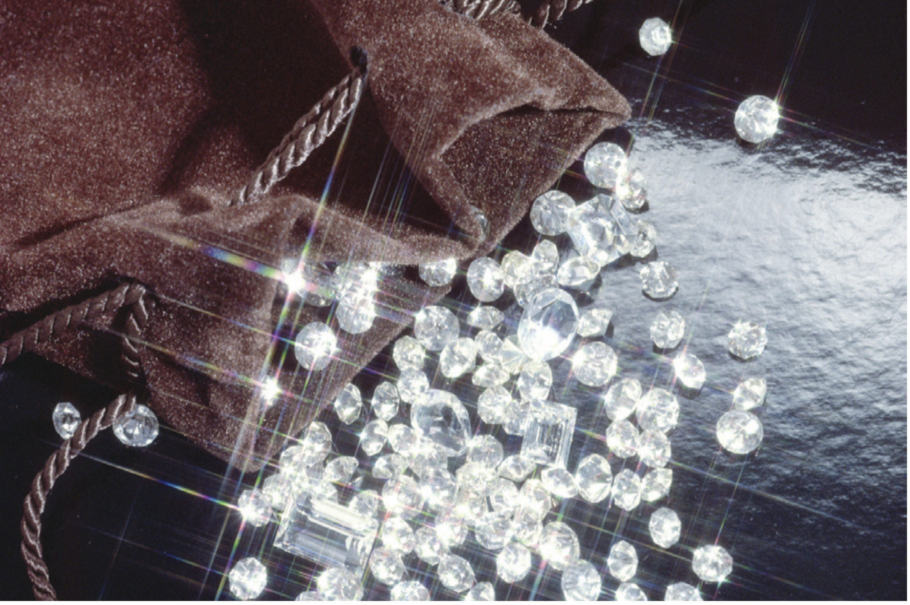

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The ethereal quality of the sparkle stems largely from its appearing to float indeterminately, neither totally above nor below nor on the surface—where we "know" it to be. It will usually appear to float above the surface. Interestingly, the illusion disappears at once when the unstimulated eye is closed. Apparently, the brain knows not to expect stereopsis when one eye is closed.

**The ethereal quality of the sparkle stems largely from its appearing to float indeterminately, neither above nor below nor on the surface—where we "know" it to be.**

The same effects can be seen at night by moonlight or artificial light, provided the light is sufficiently small and far enough away. Occasionally, light will be refracted into a crystal and dispersed on its way out. In that case, you will see colored sparkles. Occasionally, two sparkles will happen to be close enough that their images can be fused. In that case, a definite depth will be perceived. However, the fused image will generally not lie on the surface, thus again providing a peculiar appearance.

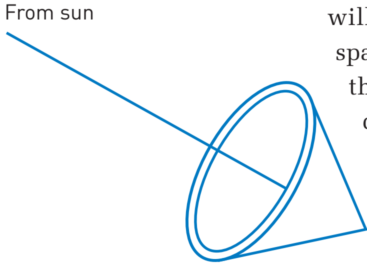
## Glitter, gems and dewdrops

Sparkles can also be seen with the glitter dust that young girls like to put on their faces or that is sometimes used to depict snow on Christmas cards. The effect can also be seen with sequins and faceted gems. Jewelers have learned by experience that diamonds show the most sparkle under small bright lights mounted fairly high. This binocular effect helps to explain why the diamonds in photographs, no matter how artfully lit, never sparkle like the real thing. (It's not just the limited dynamic range.)

It is curious that the sparkle effect appears to have escaped notice until now, while much rarer phenomena such as the green flash and the glory have been known for centuries and understood for years. I propose reserving the term "sparkle" for this narrow-beam effect, leaving such terms as "glint," "glisten," "gleam" and "shimmer" for the broad-beam reflections from curved surfaces such as icicles, ice-covered twigs and ripples on water.

Dew drops can also produce the sparkle effect—but by a different mechanism. Sparkles will generally be found only in the "dewbow"—an ellipse or arc on the ground along which the dew sparkles in color. (The rest of the dew merely glistens white.) They are caused by the same mechanism that cause rainbows. To simplify somewhat, a spherical drop emits an annular conical beam with a half angle of 41°, and a thickness of 2°, as shown in the figure to the left. The color varies from red to violet across the thickness. When an eye is within the thickness of the sheet beam, it receives just a narrow bundle of rays from this beam of one color; let us call this a "ray." It also receives rays from different parts of the cones of other drops. The locations of these drops trace out a bow in the sky (rainbow) or on the grass (dewbow).

It is more difficult to observe sparkle with dewdrops because the line connecting the two




**DEWDROP REFLECTION**: A spherical water drop emits an annular conical beam with a half angle of 41° and a thickness of 2°. The color varies from red to violet across the thickness. When an eye is within the thickness of the sheet beam, it receives just a narrow bundle of rays from this beam, of one color, or a "ray." It also receives rays from different parts of the cones of other drops. The locations of these drops trace out a bow in the sky (rainbow) or on the grass (dewbow).

It is more difficult to observe sparkle with dewdrops than with snow because the line connecting the two eyes must be more or less perpendicular to the sheet beam, and the greater beam thickness of 2° requires the observer to be closer to a dewdrop than to a snow crystal.



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eyes must be more or less perpendicular to the sheet beam, and the greater beam thickness of 2° requires the observer to be closer to a dewdrop than to a snow crystal. When both eyes are within the sheet beam and seeing different colors, the effect is interesting but does not seem to prevent fusion. Some simple experiments with different-colored dots have confirmed that they can be fused and indicate a definite distance. It might be interesting to explore whether it is more difficult to achieve fusion in such a case.

A white dewdrop can sparkle if it is hidden from one eye by a blade of grass.

Once you know how to recognize them, you may start noticing sparkles everywhere—on granite, sand and even on asphalt, mostly arising from bits of mica. Many more spots glisten but do not exhibit the sparkle effect; their beams are too broad, probably because they have curved surfaces; a thin flake of mica is easily bent. The sparkle effect can also be observed with a glitter-coated card. Use the sun or any other small-angle light source. Tilting the card makes the sparkles appear and disappear rapidly.

Part of the impact of laser speckle is from the sparkle effect, a binocular difference caused by narrow-beam scattering. But aside from that, laser speckle is a much more complex phenomenon involving interference.

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## Capturing sparkle

Hopefully these insights will help diamond photographers to realize that stereo photography is needed to capture sparkle. This does not mean that a 3-D viewer must be packed with each jewelry catalog; two photos can be printed side-by-side as a stereogram for cross-eyed viewing. Even so, the dynamic range will be severely limited in print; slides are much better, as are LCD displays.

Because sparkles have not been understood until now, theaters probably have not been able to make realistic snow sparkles in their productions—only glistens (which are equally bright to both eyes). The reason is that theater light fixtures typically have lenses several inches in diameter. Trying to use those with sequins or the like to make sparkles results in excessive reflected beamwidth except maybe for patrons in the first few rows. The beams can be narrowed by removing all lenses and mirrors from the fixtures, using very compact lamps, and hanging them far back from the stage.

Knowing about and looking for the ethereal nature of sparkles can make you more aware of them and enjoy them more—I know it has for me. OPN

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