Leach *et al.* Reply: We agree with the explanation provided in the preceding Comment [1] that the shift can be seen as the optical delay between the two different paths. Indeed we say as much in our original Letter. However, we maintain that it is possible to explain optical phenomena equivalently in different frames of reference.

As we discussed, rather than working with a moving medium [2–4], we chose to simplify the experimental task by working with a moving light beam transmitted through a stationary medium. In our earlier work [5] we showed that the rotary drag work of Jones [2] was compatible with a treatment of the image in terms of a decomposition into the constituent orbital angular momentum modes, specifically the superposition of modes with opposite sign of orbital angular momentum given a petal like intensity structure. In this case the rotating petal pattern is identical to a frequency shift between the two modes of opposite handedness and it is this fact that we apply in the Letter under discussion. Indeed, this argument is equivalent to relating an amplitude modulated sine wave to the interference between two sine waves of slightly different frequencies. In this respect we disagree with the comment made by Unnikrishnan [1], in that we do regard the rotation in the lab frame of a petal pattern formed between two OAM modes as being the same as the interference between the same two modes but shifted from each other in frequency. We assert that over a restricted field of view this equivalence argument applies also to the straight line fringes.

Also, in a subsequent work, some of us performed an equivalent experiment using a rotating ruby rod, which acts as a slow light medium, and a stationary, cylindrical light beam [6]. The measured experimental data is in complete agreement with the interpretation offered in our original Letter.

In conclusion, we agree that the effects we observe can be explained in different reference frames, but the point of our Letter was to highlight the relationship between moving media and moving images and the subtlety that this transformation requires, while offering a consistent explanation for both the linear and rotational moving pattern.

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[1] C. S. Unnikrishnan, preceding Comment, Phys. Rev. Lett. **122**, 139401 (2019).
[2] R. V. Jones, Proc. R. Soc. A **328**, 337 (1972); **345**, 351 (1975).
[3] M. A. Player, Proc. R. Soc. A **345**, 343 (1975).
[4] J. B. Götte, S. M. Barnet, and M. J. Padgett, Proc. R. Soc. A **463**, 2185 (2007).
[5] M. Padgett, G. Whyte, J. Girkin, A. Wright, L. Allen, P. Öhberg, and S. M. Barnett, Opt. Lett. **31**, 2205 (2006).
[6] S. Franke-Arnold, G. Gibson, R. W. Boyd, and M. J. Padgett, Science **333**, 65 (2011).

