

Fire in a crowded theatre

After I finished my PhD, I accepted a position at an institute called the Combustion Research Facility. As I was a laser physicist and had never done any formal coursework on combustion, I enrolled in a course there to catch up.

During one of the first classes, I learned that fires can propagate in a variety of ways. One of the most common is diffusion – a well-known, very slow, random process. Another is advection, in which the burning material flows en masse, like water in a river. Finally, there is convection, which is a combination of diffusion and advection. And, of course, the extreme case of very fast advection is an explosion, in which the flow is so fast that only an action-movie star can outrun one (and then, of course, only in movies). Indeed, I learned in class that during the blaze that struck the MGM Grand casino in Las Vegas in 1980, fire propagated via extremely fast advection through the main casino at a speed of greater than 5 m s^{-1} . Victims were found still holding their cards in their hands.

That weekend, to help rid my mind of that grisly image, my wife Linda and I went to see a movie called *Moonstruck*. It was a very popular movie, and by curtain time the movie theatre (as we call it on this side of the Atlantic) was packed. We were, however, able to find great seats right in the centre of the theatre.

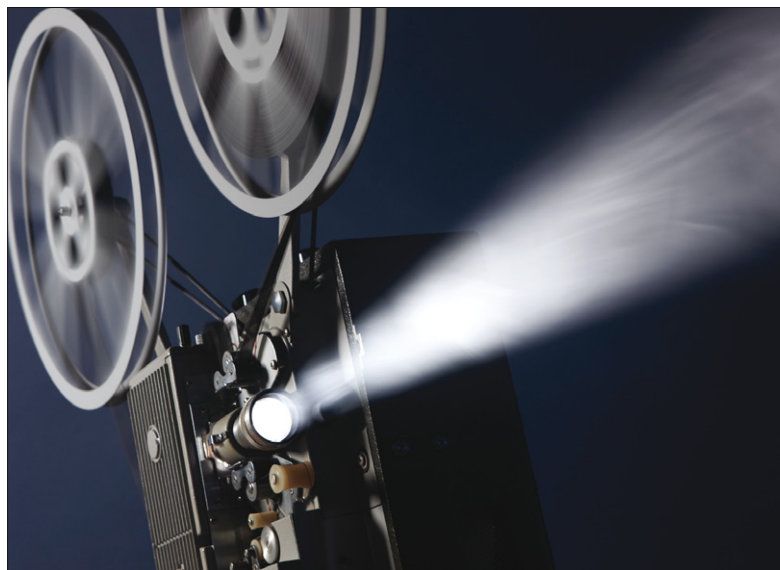
Moonstruck is about the travails of an Italian family in the US. Unfortunately, as an American who is himself half-Italian, I'd seen it all before and was utterly bored. I found myself looking around the theatre, admiring its sconces, curtains and exit signs – all of which, alas, I'd also seen before.

Then I looked moonward and was quickly struck by something I had not seen before: the theatre was rapidly filling with smoke! The upper few metres of the theatre were already thick with it, and more was rushing in. Worse, because everyone else in the theatre was absolutely enthralled by the critically acclaimed movie, not a single other audience member seemed to be aware of the disturbing fact that the theatre was *on fire*.

What to do? I vaguely remembered reading something years earlier about yelling “Fire!” in a crowded theatre. Indeed, had I taken any history courses, I might have learned that individuals falsely yelling “Fire!” in crowded theatres have caused mass panics resulting in numerous deaths on several occasions. And had I taken any law courses, I might have learned that the hypothetical example of falsely yelling “Fire!” in a crowded theatre has played an important role in legal discussions of free speech for almost a century, and is frequently cited as an obvious example of an occasion when one should not have the right to unfettered free speech.

But what if there is an *actual* fire? The legal texts aren't so clear on that one. And in that intense moment, my mind was even less clear. Had I taken any acting courses, I might have quickly come up with a brilliant James Bond-style action-hero plan. But we physicists are trained to think carefully and methodically, not impulsively and heroically. On the other hand, action heroes are, of course, fictitious, and in reality the best plan actually always results from detailed knowledge of the situation. And that I had.

My new-found combustion-propagation knowledge quickly kicked in. Yelling “Fire!” seemed sure to generate an information explosion and an analogous panic-



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filled human explosion – and almost certainly a highly undesirable, trample-filled result. But allowing the information to slowly and randomly diffuse through the theatre could be even worse because the fire could itself explode at any moment, as at the MGM casino. What I really needed was for the information to convect at a reasonable speed through the theatre, and we humans to then convect out of it. But how to accomplish this?

There wasn't a lot of time to think about it. Winging it, I quickly whispered to Linda, as calmly as I could, “The theatre is filling with smoke. We need to leave. Could you quietly whisper this to the people sitting next to you?” She did so, remaining unruffled, and we did the same to everyone we walked past on our way out.

The result was that the information convected almost perfectly radially outward through the theatre, propagating to the far reaches of the densely packed crowd in about a minute. Within another minute, everyone had calmly convected out of the theatre after us. I've never seen a more peaceful, orderly emptying of a crowded theatre.

A theatre employee whom we enlightened as we emerged called the local fire department, which quickly arrived and put out the fire. It had occurred near the theatre's air-conditioning unit, which had advected the smoke into the theatre. Fortunately, aside from the smoke, the fire hadn't actually affected the theatre itself, so, once the smoke was advected out of it, we were all allowed to convect back in to watch the remainder of the movie.

Now, I certainly do not begrudge Cher the Oscar she won for her role in *Moonstruck*, but, as I watched its conclusion, it didn't get any more interesting to me, and I've long since forgotten its story. But the concepts of diffusion, advection and convection are forever burned into my memory.



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