

SCIENTIFIC TERRAPIN

UNIVERSITY OF MARYLAND

UNDERGRADUATE RESEARCH JOURNAL



Spring 2010

Vol. 1, Issue 1

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Special Thanks to

Dr. Francis DuVinage
Ioana Stoica
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Letter from the Editors

Welcome

Welcome to the inaugural issue of *Scientific Terrapin*, the University of Maryland's first interdisciplinary research journal dedicated to undergraduate research. As two undergraduate researchers ourselves, we are strong proponents of research both from a professional and personal standpoint. The skills that research imparts, hard work ethic, spirit of inquiry, communication and writing skills, are those we think all undergraduates can learn from as they prepare to enter the world of employment, graduate or professional school. However, despite the hundreds of hours of hard work and diligence we and other undergraduates devoted to our work, the, we found that the culminating products of these efforts were seen by only a few people. We felt like that these authors deserved sufficient readership with which to disseminate their findings and inspire academic discussion.

The confluence of all of these factors inspired us to create *Scientific Terrapin*, whose mission is twofold: to provide an outlet for the publication of high quality undergraduate research in all fields (humanities, social sciences, physical and applied sciences and life sciences) to showcase the talents and efforts of undergraduate students here and to increase the visibility of undergraduate research on campus and in doing so, further the goals of University of Maryland as a research university.

This journal has been the result of a year's hard work and dedication from those who first believed in us and in the mission of this journal. From its inception, the vision for this journal has been shaped by a small, core group of students with a range of background and experience. We could not have accomplished this feat without our dedicated staff of editors, writers, advisors, and design team, and the finished product has truly been a collaborative effort. As entirely student staffed and led organization, we would also like to thank those who have shown enthusiasm and provided support for this mission. Through these months of hard work, it has always been encouraging to see our idea take root and generate excitement and interest.

In keeping with our goal of increasing the visibility of undergraduate research on campus, we have hosted workshops on finding research opportunities on campus and next year will continue to host these sessions to make research more accessible to you. We will be accepting submissions for the fall issue of the journal throughout the summer, so we encourage you to submit your abridged Honors theses or Gemstone papers, your work with a faculty mentor or campus, or your findings from an internship. Details and submission guidelines can be found on our web site, www.scientificterrapin.org. This fall, we will be looking for interested and dedicated individuals to continue to carry the torch, so we also encourage you to apply for positions on next year's staff. We are still in the beginning stages of this process and welcome all feedback in hopes to constantly work to better the journal and our practices for the future.

In this issue, you will find the work of three dedicated researchers in the social and applied sciences, as well as interview with faculty members who share how their experiences in research have contributed to their careers and their lives. Thank you for reading, and we sincerely hope that you enjoy what we have worked so hard to produce over the last year.

Sincerely,
Baijia Jiang and Jasjeet Khural
Editors-in-Chief

About Us

Mission Statement

The University of Maryland, College Park has recently been emerging as a top national research university. It is consistently named as one of the top fifty research universities and one of the top twenty-five public research universities in the nation. The university garnered \$401 million dollars in research money in 2008, funding faculty and graduate investigation of our world from the myriad perspectives of scientists, sociologists, businesspeople, historians, and artists.

However, for the University to fully reach its potential as a top research institution, we believe that undergraduate students should play a more central role in the discussion, exchange, and visibility of research on campus. Currently many undergraduate students complete Honors Theses, Gemstone Theses and conduct research in labs on campus. Before now, though, there have been few outlets for students to share their work with the rest of the community and engage in the academic discussion and debate across specialties that sharing of research confers. It is this very “culture of research” that we wish to promote. Scientific Terrapin salutes student researchers for their initiative, their dedication, and their pursuit of knowledge and, thus, will fill this void by offering an outlet for student researchers to publish their work across all disciplines, including:

- The Life Sciences – biology, chemistry, and ecology
- The Applied Sciences – engineering, mathematics, and computer science
- The Natural Sciences – physics, geology, and astronomy
- The Social Sciences – economics, government and politics, psychology, business, and sociology

Scientific Terrapin provides a stepping stone for scientists across disciplines at the beginning of their research careers. We seek to provide undergraduate researchers a forum to present their work and receive peer and faculty review, as well as readership and recognition. We seek to connect student researchers with one another, so they might form intellectual partnerships and friendships, and so will sponsor workshops and presentations to not only encourage interdisciplinary discussion and debate, but to share research opportunities and practical advice for advancement in their fields. We herald the work of promising young minds and extraordinary mentors, allowing the community to learn about exciting research produced at the University of Maryland. And last, we hope to inspire students as they enter the university or continue with their education, to take the next step and join their fellow classmates in contributing to this culture of research and to claim their integral role in the vibrant and dynamic research at the University of Maryland. ■

Q&A

Dr. John P. Fisher

Interview by Adam Pampori



Vladislav Belyy

FACULTYBIO

Dr. John P. Fisher serves as the Associate Chair and Director of Undergraduate Studies at the Fischell Department of Bioengineering, as well as Co-Editor-in-Chief of *Tissue Engineering: Part B*. He directs the Tissue Engineering and Biomaterials Laboratory at the Fischell Department of Bioengineering, where his research focuses on the interaction between biomaterials and tissue in order to develop engineered constructs for future clinical applications. He has been featured on the Discovery Channel and has received numerous awards, including an NSF CAREER Award (2005), an Outstanding Graduate Alumnus Award at the Rice University Department of Bioengineering (2007), UMD Life Science Invention of the Year (2007) and Best Invention Pitch at UMD Bioscience Day (2009).

After college, what made you decide to enter research?

I went to college at Johns Hopkins University, where I actually had a pretty challenging time. I double majored in Chemical Engineering and Biomedical Engineering, which probably wasn't the best strategic choice for my GPA or my sanity!

I got done with school, and I wasn't sure what to do afterwards. I applied to some jobs, but my father suggested that I apply to some graduate schools. He suggested the University of Cincinnati. At Hopkins, I had worked in a lab, but mainly for money to help pay for school. I only did data analysis, so at Cincinnati, it was the first time I experienced a research lab. I found I enjoyed it, and in contrast to classes, I found that it was something I could excel and do really well in. I really liked that it was self-driven; your success in lab was completely a function of your efforts, motivation, and creativity. And your failure in lab was a result of a lack of these things.

I did pretty well there, and I started to think about going into academia and research. I decided the best way to do that was to go into a top bioengineering program. I finished my Masters and went to Rice University, which has one of the top programs in the country. I did well there, did a short post-doc, and got a job as a professor.

So your father gave you the idea?

He initiated it, and I happened to find out that it appealed to me. I was completely unfamiliar with graduate school: how it worked, the mechanics, the management of it, and the research aspect. I didn't know anything about it until I got there, and I didn't know it was so distinct from undergraduate education.

You're co-Editor-in-Chief of one of the major journals in your field. How did that happen?

[laughs] My advisor in graduate school started *Tissue Engineering* in the late '90s. They had always published review papers, but after I'd been here at Maryland for a couple years,

they decided to get a person dedicated to managing the review papers that came into the journal. So he asked me to be the reviews editor for the journal, so I did that from late 2006 to 2007. Then the journal decided to split into 3 parts: Part A for research papers, Part B for review papers, and Part C for methods papers. They asked me if I wanted to be the editor for Part B, since I had been working with review papers, so I said sure.

So something like the right place at the right time?

A little bit of that, and a little that when you're given opportunities, if you do them well, they can grow into even bigger opportunities. I'd say half and half.

You've directed an REU program here at College Park for several years now. How has that experience been for you and your students?

The REU program brings 10 students from around the country to work in labs, predominantly in the School of Engineering, but also in other labs. The program was first started by the former Chair of Chemical Engineering, Tim Barbari (now Dean of the Graduate School of the Arts & Sciences at Georgetown University). When he left, I was asked to keep the program going, and got it funded through NSF. It's a great program; we get a lot of applications: roughly 200 applications for 10 spots each year. We try to focus on students who have had more limited opportunities for research. We do occasionally take students from obvious research-heavy institutions, but we try to focus on students who come from other institutions, like 4-year undergraduate colleges or liberal arts programs, who don't have access to engineering programs or these kinds of things.

It's been great because we meet a diverse group of students every year. It also benefits us as a department and the university as an institution, because many of these students, who are very good and successful, apply to our graduate school. We have a number of former REU students in our program now.

You wear a couple different hats: Editor, Director, and Principal Investigator. How do you handle all your responsibilities?

I try to be organized and efficient. That's the only thing I do really well, being organized and efficient. I'm not especially brilliant, but I can do those things pretty well. Some of those roles don't take as much time as one would think, as long as you just sit down, do what you need to do, and move on. What I find is that people have the biggest problem doing multiple things, because you don't start and complete a task and move on. If you let tasks linger over days and weeks, that's when problems arise.

For example, if you say okay, this morning I'm going to do everything I need to do for the journal, and get everything done and up-to-date. You can do that in a matter of hours, and maybe not have to revisit it for a week. The same goes for undergraduate studies stuff. If I prepare for meetings or a workshop, I do that and move on to other stuff. The same thing goes with teaching: You have to do an excellent job teaching, but you can't let it consume your time. Any of these positions can consume all of your time, if you allow it.

Probably the hardest task is research, because you have to work with students in the lab, write proposals to get funding, make sure papers go out and get revised when they get back. Staying on top of that is probably the hardest, and what you need to focus on the most.

You have some really interesting projects going on in your lab. Can you outline them for us?

Our lab does tissue engineering, biomaterials, and stem cells for tissue engineering. Our major applications are in bone and cartilage, but we also work with skeletal muscle. We use principles of polymer science, materials, fabrication, characterization; we do a lot of cell and molecular biology. We also do *in vivo* models of our engineered constructs.

The major hypothesis we aim to evaluate is that if we take a cell population and present it on a biomaterial scaffold as an engineering tissue, we make the claim that the scaffold, that biomaterial

environment, fundamentally alters the way that cells communicate with each other. If we can understand the relationship between the material properties and inter-cellular communication, as well as expression of autocrine and paracrine signals, of receptors, diffusion of these signals and of other aspects, if we can understand how they're affected by the surrounding biomaterial environment, perhaps we can use different biomaterial properties to drive particular cellular outcomes that we're interested in. Whether it's the differentiation of a mesenchymal stem cell to an osteoblast, or the expression of extracellular matrix by an adult chondrocyte for cartilage regeneration. That's the basic idea we evaluate in most of our projects. We do have very different projects going on in this context. We have projects involving bioreactors, co-culture, etc. We like to frame our questions in that context: the relationship between material properties and intercellular communication.

You've been pretty successful in grant writing-

[laughs] Not really.

What do you mean?

Grant writing is just a matter of persistence. I have submitted 68 proposals by my count, since I arrived in 2003. If you get funded 10-20% of the time, you're doing an excellent job. The problem is getting over the 80-90% rejection. There's not much you can do; you'd think you'd get used to it, but you still get bummed out every time something gets rejected. It seems like there's a typical course of events: You start writing a proposal, you don't think it's very good, but as you get closer to getting it done, you start to feel that it's this one, this one is going to get funded. Then it comes back, it gets rejected and you go, "What happened?"

As much as we'd like to think that the review process is absolutely objective, it is significantly subjective. Who gets your proposal review, how much they know about your field, and how familiar they are with your work can have dramatic impacts on the outcome of your proposal. You can't take it personally; you just move on and keep on trying.

Going back to what we talked about in the beginning, I think one of the best things I learned in college because I struggled, was persistence. Because it was a

challenge for me, I got familiar with failure [laughs]. Some of the hard times people have as assistant professors, they never had failure before. They were the leading students in college, in high school, and then they write their first five proposals and they all get rejected. It might be the first time in their lives they're told "you're an idiot" or "this is a horrible idea." Luckily I've been told I'm an idiot since high school [laughs]. But that's all it comes down to: persistence.

What would you suggest to undergraduate students who want to pursue a career in research?

Just that: get started. Get into a lab, find a lab to work in that you're excited to work in. If it's what you want to do, and you're excited about doing it, I think it will work out. As long as you keep working and continually set new goals and achievements, and never be satisfied with only what you have done.

I don't remember who it was, but I once heard someone when he was asked how he became such a successful researcher and professor, and he said, "Some people are happy to get a PhD. Those people got one, and then didn't do anything with it. There are some people who are happy to become an assistant professor, or people who are happy to get tenure and get promoted. There are some who are happy with becoming full professor, but if you're the kind of person where you're happy for all of these things to happen, but you're never *satisfied*, you'll always want to take the next step." And if you'll always want to take that next step and continue learning new things, then I think you'll continue doing that. ■

Q&A

Dr. Raymond J. St. Leger

Interview by Jenny Wang and Rosie Zhang



Natasha Savranskaya

FACULTY BIO

Dr. Raymond John St. Leger is a professor in the entomology department as well as the principal investigator of his lab. His research focuses primarily on entomopathogenic fungi, or parasitic fungi that can severely damage insects. By examining the evolution of insect pathogenicity, the underpinnings of animal and human disease can be extrapolated. St. Leger also investigates fungal toxins and genetically engineering fungi to target specific pests, like the mosquito. St. Leger was named a Distinguished Scholar-Teacher for the 2009-10 school year and gave a lecture on the “Superpathogen: Using Genetic Engineering to Build the Ultimate Mosquito Swatter.”

How did you get into entomology?

If you look at people from a distance, they all look different. But close up, they're all the same. Insects, on the other hand, from a distance, all look the same, but close up, they're all different. So what's more interesting: insects or people?

Do you study a specific part of insects?

The paradox of working with insects is that the easiest way of getting money to study them is by looking for ways of killing them. Most people who work with insects do so either for their intrinsic importance—in agriculture or as carriers of disease—or because they're a great model system—you'll know that *Drosophila* for example is the basic model for genetics and developmental biology.

So, much of my work over the last couple of decades has been on using them as a model hosts to understand how pathogens evolve. You can look at pathogens of insects and you can say, “Okay, why is that pathogen specific to that insect? Why is another pathogen specific to another insect? What does it take to jump from one host to another? What genes are involved in this host switching?” Using insects as hosts has become a model for how pathogens adapt to us. What changes are likely to happen in our pathogens?

And insects have no more friends than a boiled egg. Students have no trouble killing them off by the hundreds. You can work with generations of insects really quickly, and lots and lots of insects in a small space—that's why they're a great model system—and very quickly evaluate the evolutionary changes which have to occur in a pathogen as it adapts to generation after generation of new hosts. You can see how a pathogen adapting to a new host, broadening or narrowing its host range, loses genes or undergoes gene duplication or divergence. You can look at what particular genes are mutating and the nature of the mutations.

So a lot of my research has been involved in speciation of pathogens—how pathogens evolve to new hosts. We don't get funding from NSF because we are intrinsically interested in insect pathogens, per se. It's extrapolation. What can we learn

about human disease, animal disease, from looking at diseases of insects?

But of course, insects are also intrinsically important. My funding from NIH basically involves control of the mosquitoes that vector malaria. Most pathogens take their time killing their host so as to get as much nutrition from it as possible and that unfortunately is also true for mosquito pathogens. But we can take a fungus and we can take genes from a spider or a scorpion or whatever, put it into that fungus and make it much more efficient and quick at killing mosquitoes. Or we can take a fungus and put into it genes that specifically target the malaria. For example, we can get the fungus to secrete human antibodies against malaria so that the mosquito is left standing but the malaria inside it is killed. This strategy would avoid the mosquito becoming resistant to the pathogen, as it has done with chemical insecticides. We are hoping to test some of our strains in Kenya in 2011.

Another one of our current projects involves targeting a particular type of longhorn grasshopper, which is doing a number on oil palms. And oil palms are even more widely grown than bananas. It's the commonest fruit out there. And for poor third-world farmers, oil palms are the best new resource they have. For the world, they're an incredible source of oil. But they're being attacked by this grasshopper. So we're engineering a pathogen to specifically target it. We will do initial field trials in Papua New Guinea. See, right now they're using a very dangerous insecticide, which is very potent, not only against insects, but against people and natural wildlife as well, so it causes a lot of environmental damage. We are therefore designing specific pathogens, which only target insects—dangerous insects and leave everything else standing. We are also developing pathogens against locusts and a beetle that is the major pest of coffee.

But our principal work is done on mosquitoes because 300 million people a year get malaria, and a couple million of them each year die of it.

What's your favorite type of research?

Well-funded research.

There's meant to be a lot of altruism in science but most scientists today are individual entrepreneurs trying to raise funding in a very difficult environment to continue their work. We used to promote solely on that basis—that a scientist could prove themselves

capable of independent research and bringing in funding. And that funding was attributed to that scientist. That's how we promoted people to associate or full professor.

Just recently it's changed because there's a new paradigm out there with teams of scientists applying for very large grants. And our particular college [CLFS] hasn't done very well getting these yet. It's why we haven't been bringing in as much money as, say, the computer and physics people have. They've got a lot of experience with integrating the large teams of people necessary for these kinds of grants. So we've fallen behind. The dean has been pushing very hard for us to adapt ourselves to this new environment.

Do you think that's the hardest part of doing research? The money?

A little bit of that, and a little that when you're given opportunities, if you do them well, they can grow into even bigger opportunities. I'd say half and half.

Did you do research as an undergraduate?

Yes, I even published a paper. I nearly forgot all about it: grooming in old-world primates. I did a study on why and how monkeys and chimps groom each other. I had a very eccentric old advisor who had worked most of his life in Africa. He was the epitome of political incorrectness, though of course we are talking about a time before PC was invented. He had this big sofa in his office—and it was very dangerous for a girl to sit next to him on that big sofa.

How do you like having undergraduates in your lab?

Oh, there's lots of them in my lab. At one time, we've had up to 13 undergrads because we do a lot of field work.

Do you have any suggestions for undergraduates who want to get into research on campus?

Ask a lot of advice over a long period to find out whether you really want to go to grad school. There are a lot of misconceptions out there, but grad school can turn out to be a very interesting place. If you have difficulty asking professors for advice, you should understand that a large part of what professors do all day is to give people advice. As for the research, be aware that failure is common, and a lot of what you try won't succeed. Your boss might have a lot of good ideas about how the universe functions, but as far as his or her little bit of the universe is concerned, it might only function in a very particular way. So a lot of the good ideas that he wants testing won't be right. Therefore it's best, if you have any possibility, any chance at all, to try several different things and don't worry if most of them don't work out; just follow up on the most promising line of research. That being said, a major pitfall for undergrads and grads alike is to attempt a project that is too big. Ask the wise people around you to help you narrow your research project once you have defined what it is.

The purpose of undergrad research is to help you get an agenda of your own and define your interests. Why do you want to do research? Where do you see yourself in ten years? Very difficult question for someone your age to answer, but unfortunately you're not too young to need to think about it. But anyway, if you've made a guess at a field or topic that you might want to study, then pick a knowledgeable professor (or teaching assistant as they usually know which faculty employ undergrads), and ask for advice on how you can get involved in research. Maybe they will send you to someone else, or maybe they won't, but it's not a bad idea to visit several labs. Ask for research papers to read and ask yourself whether you would like to write such things. Undergraduate research can take many forms and most likely you will have to make opportunities for yourself by exploring options with various professors. Do you want to have a niche role in a large program or develop your own project? If you want a project of your own then you will need a good relationship with your supervisor but you should also get to know other people in the area because that will make it more interesting. ■

Social Sciences

Ethnic protest and rebellion in nominal, transitional, and consolidated democracies

Benjamin MacWilliams¹ and Dan Murphy¹

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A U.S. Department of Homeland Security Center of Excellence

University of Maryland College Park

ABSTRACT

Measuring protests and rebellions staged by minority groups relates directly to the civil unrest of a country. Scholars have used civil unrest to study the volatility of democracies in relation to how intense conflict becomes and what type of regime the government ascribes to (e.g. democracy, authoritarian, etc). However, no research has disaggregated protest and rebellion data to study the frequency of unrest in these varying regimes. Based on a review of the literature, it was hypothesized that countries transitioning into democracy will have a higher frequency of rebellion due to their instability. Additionally, fully democratic states will theoretically have a higher frequency of protests since they provide a median for peaceful protest. To test the hypothesis, three different categories of democracies were identified: transitional democracies, consolidating democracies, and consolidated democracies. Transitional democracies have recently adopted democratic qualities after being authoritarian; consolidating democracies are moving toward being completely democratic; and consolidated democracies are fully democratic. The analysis found the frequency of protests is not significantly different between the three different categories; therefore, it disproved part of our hypothesis. Rebellions in transitional and consolidating democracies are significantly different, with more rebellions occurring in less democratic countries. It is concluded that transitional democracies have potentially destabilizing factors with respect to violent rebellions.

AUTHOR SPOTLIGHTS

Benjamin MacWilliams is a junior Government and Politics major. For the past year he has been researching ethnic protest and rebellion using the Minorities at Risk (MAR) and Minorities at Risk Organizational Behavior (MAROB) data sets. Currently, he is interning with MAROB, a joint project of the Center for International Development and Conflict Management (CIDCM) and the START, researching violent ethnic organizations in the Middle East. This summer, Benjamin will be attending the American University in Dubai as a William Jefferson Clinton Scholar. After graduating, Benjamin hopes to study Arabic in Egypt and then go to law school.

Dan Murphy is a double degree candidate for Criminology and Criminal Justice and French with a minor in Terrorist Studies. From interning for diverse positions within the criminal justice system and federal government, he has gained a broad understanding of various government organizations. Early experience with the police and prison systems in Arizona sparked an interest in the treatment of minorities in the criminal justice system and the repeat-offender cycle. As a College Park Scholars Public Leadership student, his interest in the subject expanded to include minority communities around the world. Studying abroad in France during the spring 2009 semester provided a new occidental perspective on minority communities. Working with the START center on the Minorities at Risk dataset is a result of these previous experiences.

INTRODUCTION

In the last few years academics have made progress in understanding the processes that lead toward peace and conversely, toward domestic conflict. Understanding the dynamics that affect whether or not a country will fall victim to civil war or become a stabilized regime is relevant for world leaders who wish to create a positive outcome of peace negotiations and influence policy makers crafting democratization initiatives. There has been recognition of the need to study regime type and frequency of civil unrest, but little empirical analysis has been done that concentrates on countries with varying levels of democracy (i.e. countries that are consolidated democracies versus transitional democracies). The problem with previous empirical studies of conflict is the intensity of the conflict has been measured annually — making measurements of the frequency of unrest impossible.

Research has been done concerning the relationship between intensity of conflict as countries move between democratic and authoritarian regimes [1], but this does not examine changes in unrest patterns between more or less democratic countries. Knowledge regarding the frequency of conflict incidents will give us a more detailed picture of how much conflict there is as opposed to how serious the conflict is. Previous research has examined the seriousness of conflict, but this does not tell us how much conflict different regimes experience [1][2]. An empirical analysis of the amount of conflict that is experienced by different democracies will give us a better understanding of the nature of conflict within various regimes. Up until today, it has been assumed that studying the seriousness of conflict is sufficient when examining conflict inside different regimes. Studying the quantity and frequency of conflict will inform scholars if there is a disparity in the research concerning the study conflict. If the findings of this report are consistent with previous theories, no relevant disparities may be assumed. Additionally, previous studies have focused on civil war and violence as a measurement of civil unrest. These are important, but they only capture the extreme incidents of rebellion; they do not show if conflict continues in a country after violence has subdued. We address this issue by including non-violent protests as a variable.

In this paper we hope to conduct a preliminary analysis of the relation between regime type and conflict frequency. First, we will describe the two variables being used: the frequencies of both nonviolent protests and more serious rebellions will determine the frequency of conflict (dependent variable) in countries with varying levels of democracy (independent variable). This is followed by a literature review which explains the relevant background to our hypothesis. It is hypothesized that transitional democracies (having recently switched from autocracies to semi-democratic countries) will have a significantly higher frequency of conflict incidents than consolidating (countries that have a substantial amount of democratic traits) and consolidated democracies (fully democratic countries). Additionally, we hypothesize that more democratic countries are prone to a higher frequency of incidents of protests (non-violent conflict) since

consolidated democracies provide more opportunities for non-violent opposition to the government [2].

CONFLICT FREQUENCY AND TYPE OF DEMOCRACY

It will be important to determine if there is a correlation between regime type (the type of democracy) and the frequency of conflict within a country. To test this, the dependent variable of conflict occurrence will be measured using a binary coding scheme. Either a zero (no incident of conflict) or a one (some form of conflict) will be coded to a country for each month of the years 2004 through 2006. This variable will be dependent on regime type (level of democracy). To determine the level of democracy (regime type), polity data from the Integrated Network for Social Conflict Research will be used to rank countries from transitionally democratic (coded 0 polity) to consolidated democracies (coded 10 polity). Transitionally democratic countries will be countries scored between zero and three, consolidating democracies between four and seven, and consolidated democracies between eight and ten.

FREQUENCY OF REBELLION: APPLYING HEGRE'S ANALYSIS

There is a general consensus amongst scholars that countries at either pole of the polity continuum — namely consolidated democracies and autocracies — experience lower levels of unrest as compared to transitional, intermediate regimes. These intermediate regimes “possess inherent contradictions as a result of being neither democratic nor autocratic” [1], and the literature suggests that this middle ground is correlated with the increased potential for unrest. Our theory builds on the analysis done by Hegre of the “relative risk of civil war as a function of democracy and time since most recent regime change, 1816-1992” [1]. Whereas Hegre's analysis uses level of democracy and time since most recent regime change to gauge a country's relative risk of civil war, our theory broadens the unrest variable considerably and disregards regime change altogether. Instead we apply the most basic theoretical assumptions of Hegre, namely that intermediate regimes are more likely to experience unrest, and apply them to all incidents of rebellion. By zooming out to include all unrest in the form of rebellion, as opposed to focusing only on civil wars, we theorize that the conditions of intermediate regimes engender a climate conducive to more violent unrest on a variety of levels. We also expand our study to include protest as a related but different form of unrest. By analyzing unrest in two separate categories — rebellion and protest — we cast a broader net than Hegre's study. Further, our study looks at the actual occurrence of unrest, as opposed to the risk of such events occurring.

It should be noted that some portion of our rebellion variable does in fact coincide with Hegre. Civil war, while rare in the data we analyzed, is included as a portion of the rebellion variable. However, our rebellion variable is much more of a catch all, including political banditry,

sporadic terrorism, local rebellions, as well as small, intermediate, and large scale activity. The inclusion of rebellion that is less organized and intense than full-fledged civil war allows us to expand on Hegre's theory and apply it to more generalized unrest.

EXPANDING ON GURR'S ANALYSIS OF PROTEST

In regards to the protest variable, our theory builds on Gurr's hypothesis "that institutionalized democracy facilitates non-violent communal protest" [2]. While we agree with Gurr, our theory investigates whether or not a correlation exists between regime type and the frequency of protest. By disaggregating the Minorities at Risk protest variable into a monthly reading, we are able to assess whether this hypothesis expands beyond the mere incidence of protest and includes frequency. We argue that if Gurr's findings are indeed accurate and consolidated democracies facilitate non-violent protest, a positive correlation between increasing polity scores and frequency of protest should exist.

An analysis of the disaggregated Minorities at Risk protest and rebellion variables will shed light on our theory that there is a correlation between a country's polity score and the frequency of unrest in the form of both rebellion and protest. As such, the empirical conclusions we draw will be narrowly focused. A discussion of other potential factors in unrest is simply outside of the scope of our analysis. Whereas Gurr measured many variables in relation to minority unrest, our analysis and theory only seek to add depth to Gurr's study of the correlation between levels of democracy and communal protest.

HYPOTHESIS

Despite the number of empirical studies that have been done about the relationship between regime type and incidence of unrest, the data that we have collected allows us to provide new insight and analysis. The first observation we have made is that in studying unrest, it is important to distinguish between protests and rebellions. Making this distinction, as opposed to merely gauging the frequency of general unrest, allows us to formulate a more focused hypothesis and, potentially, draw more meaningful conclusions. Secondly, our argument centers on the idea that the frequency of protests and rebellions can be just as important for scholars and policy makers to study as the intensity or mere incidence of unrest. From these two distinctions, we theorized that transitional democracies will experience a higher frequency of rebellions. This hypothesis applies Hegre's theory that transitional regimes "possess inherent contradictions as a result of being neither democratic nor autocratic" [1] to the frequency of rebellion, arguing that those contradictions create an environment that is conducive to higher levels of violent activity. If transitional regimes possess certain elements that make incidents of rebellion more likely, it follows that this can be measured in the data by a higher frequency of rebellion in these countries. In regards to protest, we theorize that consolidated democracies will experience a higher frequency of protest

because of the relative openness of society as compared to consolidating and nominally democratic states. If this theory holds, the frequency of protest should decrease as one looks at progressively less democratic states.

Apart from the distinctions we make between protest and rebellion as well as intensity and frequency, our theory rests on the notion that there is a correlation between regime type and the frequency of protests and rebellions. In order for our data to provide meaningful analysis of this complex issue, we must first prove that any correlation that does exist is statistically significant. If we are unable to prove the statistical significance of this correlation, further work will have to be done to find any possible linkages.

OPERATIONALIZATION

To measure the level of democracy, each country is ranked annually by a score between zero and ten. A country with a score of zero means it is nominally democratic with some authoritarian traits, and countries with a score of ten are purely democratic [6]. The independent variable of frequency of conflict is split into two measurements: protests and rebellions. Both of these are actions that are directed toward the government, but rebellions have a violent characteristic that is generally not present in a protest. Transitional democracies should be observed to have a significantly greater frequency of conflict incidents since they are less stable. A pressing rival hypothesis to our paper is the null hypothesis that there simply is no significant difference between non-violent and violent conflict in relation to democratic regime type. This rival hypothesis is personified by the previous literature's refusal to acknowledge this distinction.

It is important to note that the dependent variable of conflict incidents (and likewise their frequencies) is measured by opposition to a government that comes from minority groups within the country. Conflict is a result of coercion which is typically toward minorities of the country. Tatu Vanhanen argues that people align themselves politically based on shared kinship and support one another accordingly [3]; from this we concluded that a government controlled by the majority will tend to oppress the minority groups in the country. Therefore, to better comprehend where the civil unrest originates, our study uses data that accounts for minority uprisings and grievances as the primary cause for civil unrest.

DATA AND METHODS

The analysis was done using the Minorities at Risk data set. This data identified minority groups from around the world and coded different variables of the groups annually. Two of these variables are the intensity of rebellions (violent attacks against the government) and intensity of protests (non-violent demonstrations against the government). Since the data was aggregated annually, it was not possible to determine if multiple incidents of rebellions or protests had occurred in one year by the same minority group. For example, in Nigeria during the 2005 calendar year, the Ijaw rebelled and protested twice,

but the Minorities at Risk data is aggregated annually to only show the most serious incident of rebellion and incident protest during that year. Additionally, the data did not account for the time during the year when the incident occurred; it only showed that something happened, at some time, in that year. To fix these two problems we recoded the data for the years 2004 through 2006 on a monthly scale. Each incident was coded based on intensity in the month that it occurred, so if multiple incidents happened in the same year they will be detected since the data is disaggregated by month. To disaggregate the data, we relied on coding notes of previous researchers and open-source data from international media and government sources [5].

The purpose of this paper is to look only at the frequency of incident occurrences; therefore, for the statistical analysis the data was recoded to a simple count of how many protests or rebellions occurred each year. The statistical analysis, therefore, will not determine which months are statistically different from others. This analysis is not relevant to the present study because the Minorities at Risk data is from countries around the world, and monthly data on relevant variables that would account for difference from month to month are not included in the analysis. The disaggregation of the data into months serves our goal of observing differences of frequencies of unrest occurrence (whether it be a rebellion or a protest) between three different types of democracies.

Three main types of democracies were identified for comparison in this study: transitionally democratic countries, consolidating democracies, and consolidated democracies. To classify the democracies the Polity IV data was used from the Integrated Network for Social Conflict Research. This data assigns a number between zero and ten to countries based on various factors that are observable in democracies. A country with a score of zero is a country with a comparable amount of authoritarian and democratic characteristics, and countries with a score of ten are considered very democratic. It was decided to identify democracy types by assigning countries with scores of zero through three as transitionally democratic, four through seven as consolidating democracies, and eight through ten as consolidated democracies. This method was used to define where transitional democracies fall in terms of answering the research question (do transitional democracies have different frequencies of conflict?). Dividing the countries into these three groups was also done for the practical purpose of facilitating the statistical analysis.

To determine statistical significance, the mean frequencies of protests in transitionally democratic countries (category 1) was compared to consolidating democracies (category 2) and then to consolidated democracies (category 3) using a two-sample t-test. Then category 2 was compared to category 3 using a two-sample t-test. The same method was used to compare the mean frequencies of rebellions between the three types of democracies. It was necessary to use the t-tests to test the null hypotheses that there is no statistically significant difference between transitional, consolidating, and consolidated democracies with respect

to their frequencies of protests and then with respect to their frequencies of rebellions. The results of these six tests are two fold: they will tell us if protests and rebellions are of equal importance and if so, between which types of democracies are they statistically significant. In other words, it will tell us if democracies with differing levels of freedom and rights have more or less incidents of non-violence and violence.

DATA ANALYSIS

Figure 1, below, shows the variation in frequency of protests and rebellions (respectively) over the period January 2004 through December 2006. Results of a statistical test on data from Figure 1 is presented in Table 1. These statistical values show that there is no statistically significant correlation between regime type and frequency of protest for all categories; therefore, we cannot reject the null hypothesis. In terms of rebellion we do observe a statistical correlation between regime type and frequency of rebellion. Based on the analysis, category one is statistically different from the other categories with regards to rebellion; however category three is not different from category two. In relation to our hypothesis, this analysis provides some unexpected results. The tests show no statistically significance correlation between protests and regime type; therefore, it disproves our hypothesis that protests will be more intense in consolidated democracies. In terms of rebellion, the correlation between regime type and frequency of unrest is seen in category one (newly democratic countries). This shows support for our hypothesis, supporting our argument that newly democratic governments possess destabilizing characteristics that make them less stable and more prone to internal rebellions.

Based on the statistically significant correlation observed between rebellion and regime type in category 1 countries, our hypothesis in regards to frequency of rebellion is supported by the data. Table 2 shows that transitional democracies have a much higher mean frequency of rebellion than either consolidating democracies or consolidated democracies.

IMPLICATIONS

The existence, or non-existence, of a correlation between minority protest and rebellion and regime type has wide-ranging implications for all countries on the continuum of transitional to consolidated democracies. From a Western perspective, drawing empirical conclusions about the frequency of protest and rebellion in transitional democracies is crucial. The Western world largely seeks to bring democracy to countries that have yet to achieve this ideal, and the ability to anticipate the trajectory of the democratization process is a necessity for policy makers. Even though our theory that consolidated democracies will have a higher frequency of non-violent protest was not borne out in the data, useful conclusions can be drawn from this portion of the study.

At first glance one might interpret the lack of a statistically significant correlation between regime type

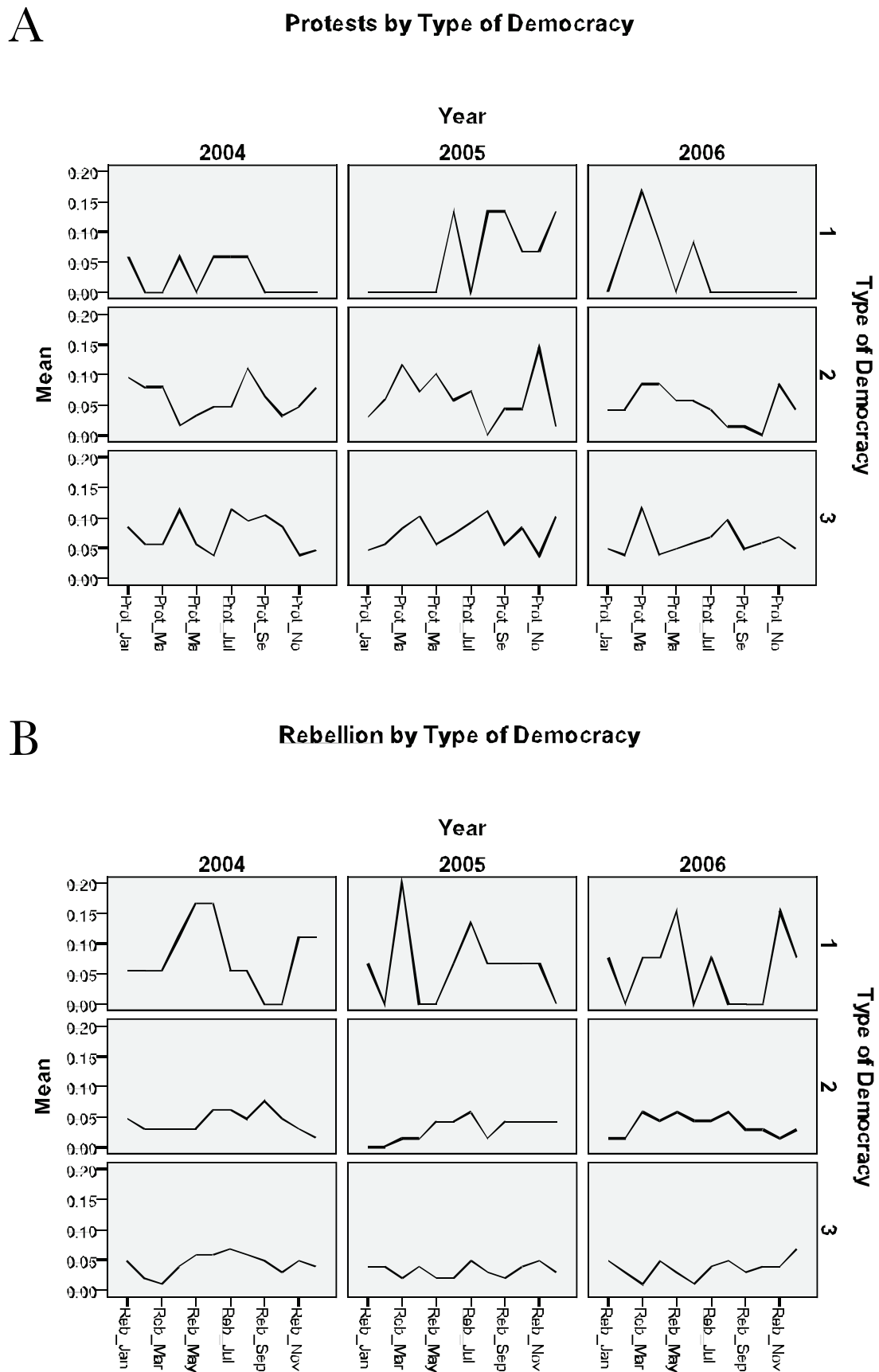


Figure 1. The mean frequency of protests (A) and rebellion (B) type 1, 2, and 3 democracies measured over a 3 year span from 2004-2006.

Table 1. T-test Results comparing protest and rebellion across type 1, 2, and 3 category democracy.

Type of Democracy	Significance (p-value)
Protest Category 1 vs 2	.923
Protest Category 1 vs 3	.503
Protest Category 2 vs 3	.225
Rebellion Category 1 vs 2	.000
Rebellion Category 1 vs 3	.009
Rebellion Category 2 vs 3	.181

Table 2. Mean rebellion frequencies over a 3 year period spanning 2004-2006 across type 1, 2, and 3 democracies.

Type of Democracy	Mean Frequency of Rebellion
Category 1 (transitional democracies)	.8043
Category 2 (consolidating democracies)	.4272
Category 3 (consolidated democracies)	.4711

and frequency of protest to mean that open society efforts to promote basic freedoms in nominally democratic and non-democratic countries could be ineffective. This conclusion is incorrect. The fact that protests occur in all three regime categories we studied regardless of the regime type is, if anything, a hopeful sign for organizations and nations that seek to promote democracy around the world. The frequency of protest in states that are nominally democratic and have some authoritarian elements shows us that despite the dangers of doing so, people will protest what they perceive as inequality. Democracy cannot be forced on a populace. The existence of individuals who yearn for more freedoms and stable institutions lays the foundation for policy makers to build upon.

Our theory of a positive correlation between an increasing frequency of rebellion and decreasing polity scores also has broad policy implications. This correlation reinforces the Western notion that large scale democratization efforts can effectively combat violent unrest and create a more peaceful world. Efforts to democratize countries with lower polity scores, including

those countries that are non-democratic, should therefore be augmented.

In our analysis of rebellion data, we found that a statistically significant correlation between regime type and rebellion frequency only occurred in category one countries. Category one countries also had the highest frequency of protest measured amongst the three segments. This correlation between regime type and rebellion, coupled with a high frequency of rebellions, sheds light on some of the potentially destabilizing affects of democratization efforts. For policy makers, the high level of violence in these transitional regimes should not serve as a barrier towards the democratization of more autocratic regimes, but steps should be taken to at the very least reduce the resulting unrest. With the knowledge that increased frequency of rebellions is a possible outcome of countries being in the transitional polity range, policy makers need to preemptively address both political and security concerns.

Prior to democratization efforts, dialogue between potentially destabilizing actors, especially ethnic minority groups, should be encouraged. While these

communications will not avert all rebellion in transitional states, it will provide the foundation for future political contacts and potentially head off some of the more easily resolved disputes. In terms of security, peace-keeping resources and aid organizations should be deployed to protect vulnerable populations. Especially in countries where unrest might precipitate security concerns for surrounding states or has the potential to provoke other international actors, it is crucial to proactively address security concerns whenever possible. Prevention will be less costly, both in terms of lives and dollars, than later intervention. ■

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Applied Sciences

Magnet apparatus for X-ray magnetic linear dichroism measurements: design and characterization

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ABSTRACT

Presented within is the design and characterization of a magnet structure critical for direct, at-wavelength X-ray magnetic linear dichroism (XMLD) measurements. To achieve these XMLD measurements utilizing an existing experimental setup, the magnet structure must yield a minimum magnetic field while fitting within limited spatial constraints. We present the basis for the spatial and field requirement for the structure, the core material utilized to achieve the desired specifications, and the process performed to arrive at the final magnetic structure. Experiments were performed to characterize the heat dissipation versus time as well as the field strength versus input current of the magnet structure.

Key terms: x-ray magnetic linear dichroism, magnet, heat dissipation

AUTHOR SPOTLIGHT



Yoav Achiam graduated in December 2009 from the University of Maryland. He majored in electrical engineering, focusing on signal processing, and minored in engineering leadership. During his studies at the university, Achiam worked as a research assistant in the Nanostructures Laboratory at the Institute for Research in Electronics and Applied Physics (where he conducted the research presented here) under the guidance of Dr. Kristine Rosfjord and in the Wireless Communications Laboratory under the guidance of Drs. Anthony Ephremides and Peter Petrov.

INTRODUCTION

X-ray magnetic linear dichroism (XMLD) is a complex, wavelength dependent effect. XMLD refers to the change in the optical response of a material when the direction of an applied magnetic field is varied with respect to an incident field's polarization [1]. These magnetic linear dichroism effects are most easily observed about absorption edges, such as those found at soft X-ray wavelengths. This phenomenon can be used to study the structure of antiferromagnetic oxides that exhibit XMLD. To date, there has been no known direct measurement of the complex XMLD.

One way to achieve this direct complex measurement is through at-wavelength phase shifting, point diffraction interferometry [2]. In this setup, the series eXclusive-OR (XOR) combination of a transmissive grating and zone plate creates two off-axis foci at the sample plane [1, 3]. One of these beams is an unmodified reference beam, and the other propagates through the material. These beams overlap at a downstream detector, creating a resultant interferogram containing the complex optical properties of the material under testing. To utilize this setup for XMLD measurements, the testing material is radiated about its absorption edge, while a magnetic field is applied to the material. The maximum XMLD effect is obtained by changing the direction of the magnetic field from parallel to perpendicular with respect to the direction of polarization of the incident radiation. A magnet structure is required to create this magnetic field that is compatible with the interferometric system. This paper describes the design and building of this magnetic configuration.

The required magnet structure must generate a field of 0.1T to ensure observation and measurement of the

XMLD effect. This field must be generated by a magnet structure that is compatible with the vacuum requirement (10-6 torr) of the interferometric system and fit into the existing vacuum chamber (a 144.7mm by 111.7mm area is available [4]). The magnet structure must consist of both a magnet and a support structure for the magnet and sample material.

Magnets that provide a field on the order of Tesla and operate in a vacuum can be found in the literature. However due to the geometrical limitations of the vacuum chamber and placement of the sample under study, the structure has to be adapted for this specific case. For example, Jarvis [5] designed a magnet system for a low temperature vacuum system. However, these magnets encapsulated the sample and thus needed a large inner core, as the magnetic field is measured inside the core. In the current setup, the core has to be small due to geometrical constraints, and the magnetic field has to be measured outside the core, as the magnets cannot block the incident soft X-ray radiation.

Several tests were done to determine the optimal core magnet material used. After experimenting with different materials, 4140 stainless steel was chosen for the core magnet material for its properties — its magnetic permeability and the option to purchase it annealed. For the support structure, 304 stainless steel was used. It was chosen between the non-magnetic stainless steel alloys due to its accessibility to the group. Other experiments were performed to measure the heat dissipation over a given time, as well as the field strength for different currents. In this paper, the researchers introduce the final design of the magnetic structure and the materials required for its construction. This includes a discussion of the core material and methods for coiling about the core. The characterization of the proposed magnet structure is also discussed.

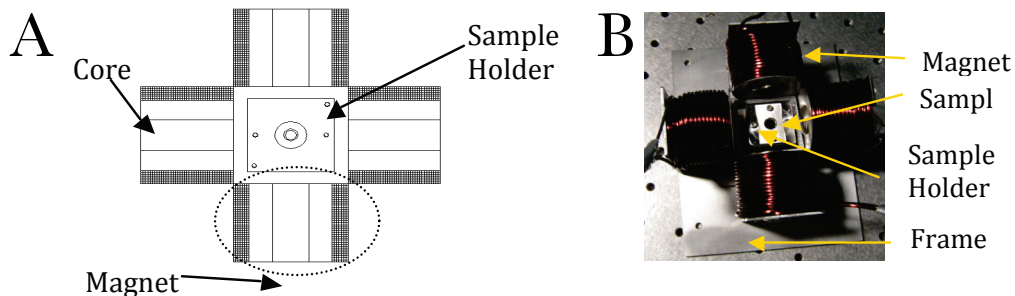


Figure 1: (A) A cross section of the four magnets and the sample holder. (B) Final assembly of apparatus showing the two magnet pairs, the sample holder, and the frame that holds

DESIGN

OVERALL DESIGN

Figure 1 displays the final design of the magnet structure. In this design, two orthogonal magnet pairs are used to create fields that are alternatively parallel and perpendicular to the sample. Each magnet consists of a 4140 stainless steel core wound with wire; switching the current through the windings allows for the turning on and off of a magnet pair and thus the required opposing fields through the sample. Each magnet is held to the sample holder using 304 stainless steel sheets (at varying thicknesses). The sample holder is also constructed from 304 stainless steel.

The field produced by the coiled magnet structure was modeled using the Biot-Savart law applied to a finite solenoid. The on-axis magnetic field, B , that is a distance, z , from the end of the magnet structure can be expressed as

$$B(z) = I \log \left(\left| r + \sqrt{r^2 + z'^2} \right| \right) \bigg|_{z'=z}^{z'=z+L} \bigg|_{r=a}^{r=b} \quad (1)$$

where L is the length of the magnet coil and a and b are the inner and outer radii of the magnet coil, respectively.

The spatial parameters of the magnet structure were determined based on the above relationship. To achieve a higher magnetic field for a constant input current, we needed to increase the length of the coil while staying within the constraints from the size of the vacuum chamber in which the magnet structure would reside. Alternatively, we could decrease the distance from the magnet structure to the sample. With our design, the two magnets pairs are positioned orthogonal to one other (see Fig. 1). Therefore, the minimum distance z_{min} to the sample, located between each pair, and the maximum loop radius b (proportional to the number of layers) are

equal ($z_{min} = b$). Additionally, increasing the number of windings about the core increases the resistance R of the coil. The heat created by the coil is proportional to IR^2 ; thus I and R are restricted by the allowed sample's temperature.

The above theoretical discussion leads to a number of design guidelines. The magnets should be as close as possible to the sample to maximize the resultant magnetic field. It is preferable to increase the number of layers to the maximum allowed by z_{min} . The length of the coil is determined such that the required magnetic field could be obtained with a current in the range supplied by the current source. The temperature of the coil, operated for 1 minute, must not exceed 100°C .

The above reasoning resulted in magnets that are 32mm long with a radius of 40mm. This radius is comprised of a core radius of 12.7mm and seven layers of wire winding on top of this core. In each layer of winding, there are 20 loops. The greater the number of layers, the stronger the magnetic field is. For that reason, a small core radius is desired to increase the number of winding layers. For ease of data collection, the sample holder was designed to allow easy access to the sample. This is shown in Figure 2.

CORE DESIGN

4140 steel was used as the core for the magnets. In order to allow maximum windings about this core, and thus a larger resultant magnetic field, a core diameter of 0.5in (12.7mm) was used. Machining steel induces change to its magnetic characteristics, specifically permeability. In order to restore these characteristics, the steel must be annealed after being machined. The core steel was purchased annealed to ensure this permeability. Initial designs with a thicker 1in core rod did not allow for enough windings within the allotted space to create the requisite magnetic field.

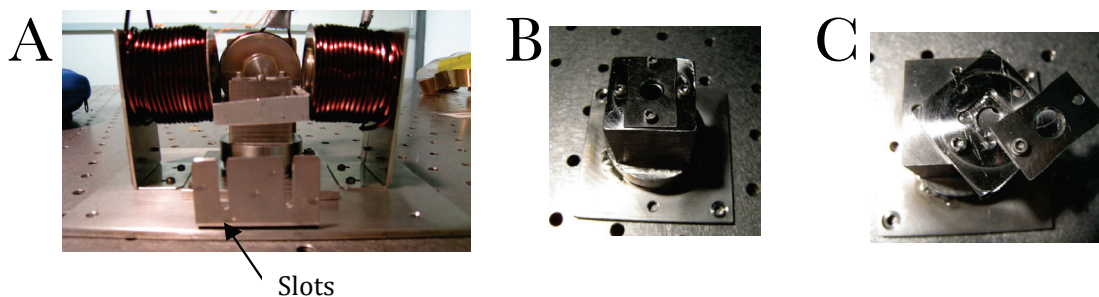


Figure 2: Photographs of the sample holder (stainless steel) with the magnet (copper) around it. (A) The magnets are mounted in a way that it is simple to remove the sample holder and change samples, (b) an assembled view of the sample holder, and (c) a view showing all the moveable pieces of the sample holder. For ease of data collection, the sample holder was designed to allow easy access to the sample.

FABRICATION

The final design uses 14 gauge square copper magnet wire with a 2.1mm² cross section. Square wire increases the cross sectional area of the wire for a given gauge as compared with round wire; this in turn reduces heat in the magnet system. As shown in Figure 3, a lathe is used to coil the magnets where the wire is attached to the lathe through an extra length of wire. This extra length of wire is trimmed before the magnet structure is used. A vacuum conducting grease, Apiezon T, is applied between layers for heat dissipation.

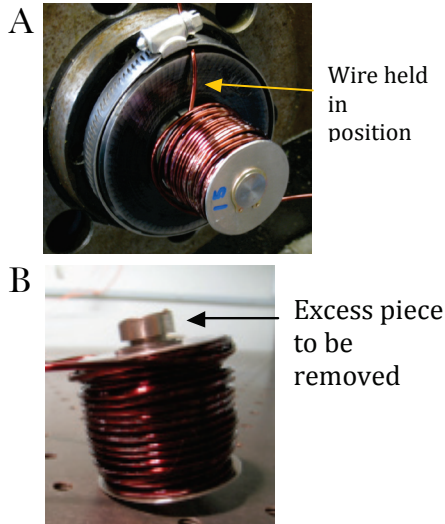


Figure 3: Coiling accessories. (A) Magnet held in lathe with the magnet wire secured in place at one end; (B) a coiled magnet with the excess piece at the top.

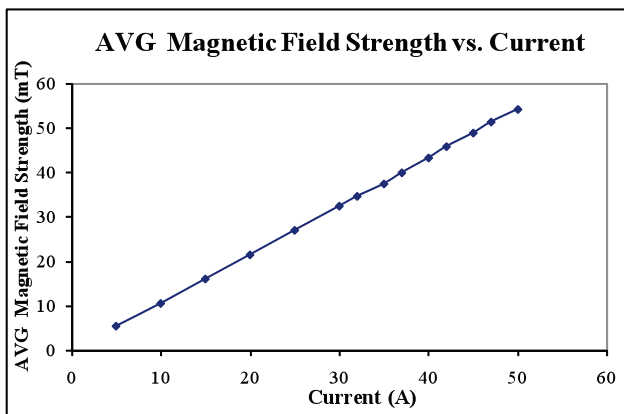


Figure 4: Magnetic field strength versus current in final configuration

CHARACTERIZATION

MAGNETIC FIELD STRENGTH

The assembled magnet apparatus was first characterized with respect to magnetic field strength versus current through the windings. The results for this field strength test are found in Figure 6. In this specific arrangement, a magnetic field of 0.05T was obtained at a current of 45A at the sample location between the two magnets. This value can be used as the starting point for the experiment series. A higher magnetic field, if needed, can be reached by increasing the current (of 0.1T at 90A), or by moving the magnets closer to each other.

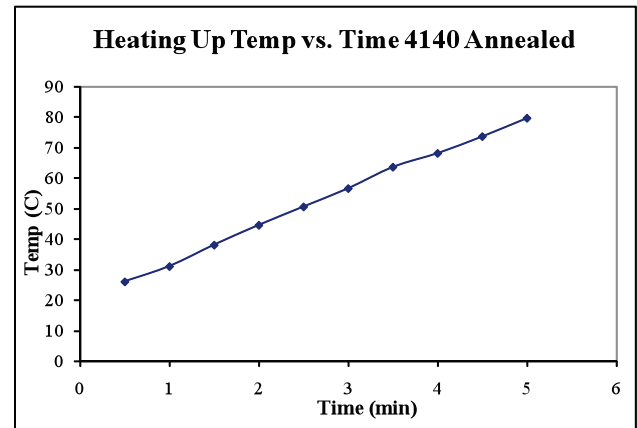


Figure 5: Temperature change of a single magnet.

HEAT DISSIPATION

Temperature increase from the magnet apparatus introduces an additional variable into the experiment. To increase the magnetic field, the current has to be increased. Increasing the current increases the Joule heating. High temperatures can cause phase and structural changes in the sample and even destroy the magnet itself. Therefore, it is important to characterize the temperature variation of the magnet as a function of time and to estimate the temperature variations when the magnet is in the vacuum chamber. Two experiments were performed with regard to the magnets' temperature in atmospheric pressure conditions. In the first experiment, temperature change was measured as current was run through the windings. The results are depicted in Figure 5.

In the second experiment the magnet was tested in data acquisition conditions. The temperature of the magnet was monitored while the magnet was turned on and off for 2 minutes, respectively. This is the time period associated with the acquisition of a single XMLD data point. The results are depicted in Figure 6.

In both temperature experiments the final temperature was close to or above 100°C, and no steady state was reached. From Figure 6 one can see that in room temperature the rate of the temperature change during

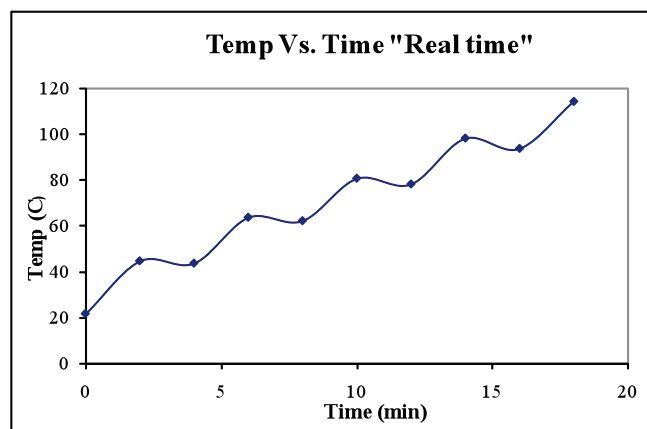


Figure 6: Temperature change of a single magnet in “on-off-on...” operation.

the heating cycle (current on) is five times more than during the heat dissipation cycle (current off). As the magnet temperature approached 100°C , the heat dissipation increased by a factor of two. During the heating cycle both phenomena, temperature increase due to input electric power and temperature decrease due to heat dissipation, occur. Smaller heat dissipation is anticipated in the vacuum conditions of the XMLD experiment.

From the results shown in figure 5, approximately 8 minutes of data acquisition is allowed with the proposed magnet configuration. This data acquisition time is within the constraints of the XMLD experiment. This data acquisition must be followed by a relaxation time for heat dissipation. Alternatively, future study with regard to heat transfer from the magnets to outside of the vacuum chamber is needed. It is suggested that copper foil be used to wrap the magnet and connect it to the vacuum chamber exterior. This would act as a means to conduct heat from the magnet to outside the chamber.

CONCLUSIONS

The magnet apparatus presented produces a magnetic field of 0.05T using 45A , the optimal current to be used, while remaining within the physical constraints of the interferometric system. It demonstrates heating characteristics that are within the two minute on-off cycle of data acquisition. The proposed structure is ready to be used in the XMLD experiment following testing in vacuum. Future research needs to be done on the effects of the heat caused by the magnet on the sample.

ACKNOWLEDGEMENT

I would like to thank Mr. J. Pyle for mechanical advice and physical help in the machine shop and Prof. John Rodgers for his guidance and expertise. ■

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